The WHAT'S NEW magazine AUGUST 1986 $1.75 CANADA $2.25

Popular Science

Earthquake prediction: Near at last?

SPECIAL SECTION: New housing technology for the 1990s

ULTIMATE TECHNO-HOME

Computer-controlled windows, blinds, energy systems
Advanced-technology solar collectors
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Sunspace heat stored in masonry walls, rock bed
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A SPA IS A SPA IS A SPA?

A CONSUMER GUIDE

If you've been considering a spa or hot tub you're probably already aware of the benefits and pleasures of whirlpool massage. However, not all spas and hot tubs are alike. The true test of any spa is whether it can provide these pleasures conveniently and efficiently. We'd like you to know what to look for when shopping for a spa and show you why the engineers who designed the HOT SPRING SPA have produced the best one available today.

1. MATERIALS AND CONSTRUCTION.

The HOT SPRING SPA is made of the most advanced and durable material of any spa—ROVEL™ This high-impact plastic is superior to wood of old fashioned hot tubs because it doesn't absorb water, leak or deteriorate. Unlike fiberglass or acrylic surfaces, ROVEL won't peel, blister, crack or delaminate. Check the warranties of other spas and you'll see that ROVEL is guaranteed to be much more durable than any other spa material. In fact, a recent industry trend has seen many acrylic manufacturers reduce surface warranties to just one year! ROVEL is softly textured so you won't slip when entering or exiting the spa.

2. CONVENIENCE AND EFFICIENCY.

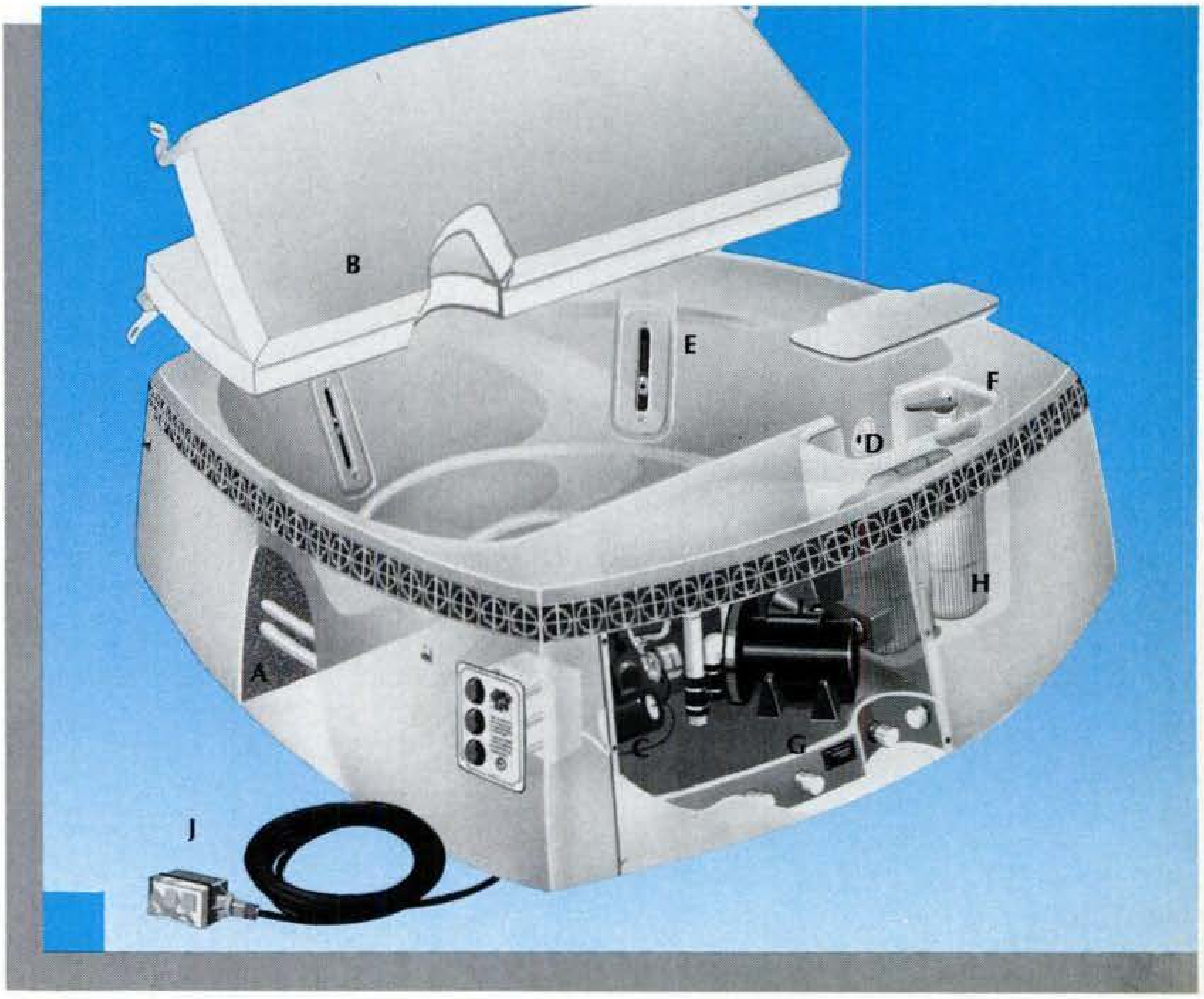
Most spas and hot tubs have very little thermal insulation, some have none at all! Just how important is insulation? It's the most important feature in private spa ownership! Uninsulated spas will physically not operate outdoors in colder climates, making spa use as seasonal as a swimming pool. Further, a marginally insulated spa forces the heater to run continuously, costing you money. The HOT SPRING SPA is FILLED SOLID with over 130 lbs. of polyurethane foam insulation **(A)** and standard equipment includes a 3½" thick insulating cover **(B)**. This heavy insulation makes it economical to keep the HOT SPRING SPA heated to your desired temperature 24 hours a day, regardless of location. You can use your HOT SPRING SPA at any time day or night, in any weather, and for just pennies.

3. TEMPERATURE.

Precise temperature control is important. A spa should control temperatures within ± 1°F. or you'll forever be too hot or too cold as the water changes temperature. The HOT SPRING SPA achieves this accuracy by using a "precise demand" thermostat with its sensor in intimate contact with the water **(C)**.

4. HYDROTHERAPY JETS.

Vigorous jet action is the key to true hydrotherapy. Only the HOT SPRING SPA gives you the option of powerful fixed jets (22 psi at each jet) **(D)**, and the unique massaging effects of MOTO-MASSAGE™ The exclusive MOTO-MASSAGE (U.S. Patent #4,523,340) glides gently up and then down the entire length of your back in a continuous sweeping motion that simulates the natural stroking of a manual massage **(E)**. In addition, we provide an air control which can be reached from inside the spa so you can vary the intensity of the jets **(F)**. These features combined with the STA-RITE Max-E-Glas pump provide the best hydrotherapy available today **(G)**.



5. WATER CHEMISTRY AND FILTRATION.

Most portable spas contain less than 180 gallons of water. It is difficult to maintain proper chemistry in such a small body of water. Therefore it is necessary to drain them more frequently than the HOT SPRING SPA which contains 275 gallons. Good filtration is essential in any spa, but in other portables, it has been overlooked. The HOT SPRING SPA has the largest capacity filter of any portable spa—50 square feet **(H)**. It requires attention only 2 or 3 times a year. Its top-loading design allows you to inspect, remove, and clean it without draining the spa.

6. LIGHT FOR NIGHTTIME USE.

Another feature of the HOT SPRING SPA is the underwater light **(I)**. It's dimmer controlled so it's never too bright or too dim, and different colored bulbs can be used for different effects.

7. NO INSTALLATION.

Simplicity of installation should be checked. An in-ground spa is the most difficult, usually requiring backyard excavation, building permits and an expensive installation crew. Hot tubs are not much simpler. The HOT SPRING SPA avoids these problems by requiring only common household current to operate (110v. 20amp.) **(J)**. There is no permanent hard wire electrical hook-up, no external plumbing to assemble, and no building permits to obtain. As a portable appliance, the HOT SPRING SPA will not increase your property taxes and you can take it with you when you move.

8. LISTED BY UNDERWRITERS LABORATORIES.

The HOT SPRING SPA is completely listed by Underwriters Laboratories, the recognized experts in testing for safety. The importance of correct and safe electrical design should not be overlooked. Check for the U.L. Mark on the outside of any spa you're considering—you'll see it on the HOT SPRING SPA.

We are proud of the quality features we build into every HOT SPRING SPA. The HOT SPRING SPA is an integrated design whose form follows function—the result of 9 years of evolution toward an ideal. So, before you buy any spa, be sure to see and test the HOT SPRING SPA. It has the features, performance, and quality you need.

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Popular Science®
AUGUST 1986 Founded in 1872/Vol. 229, No. 2

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Cover photo by Jeff Austin

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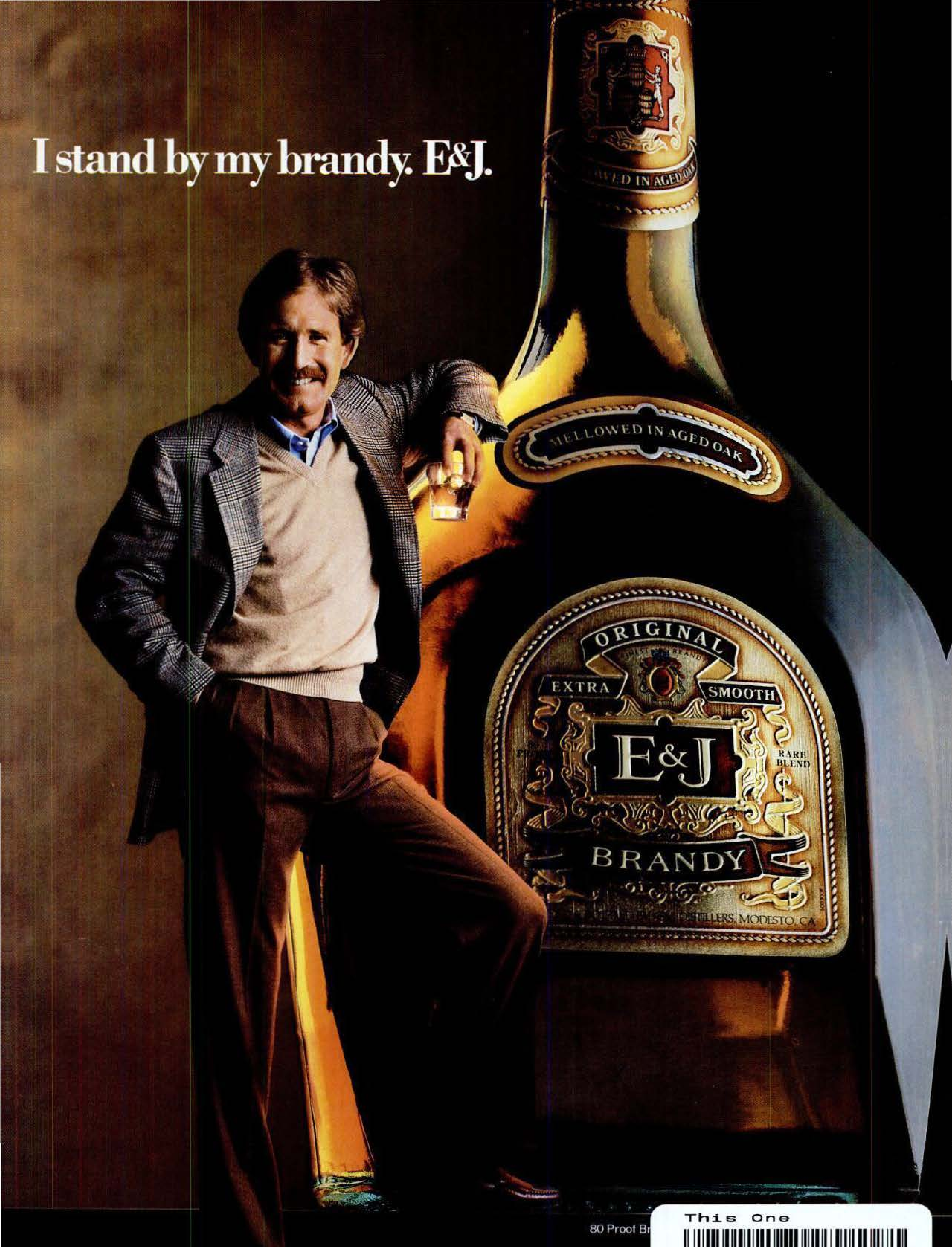

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Readers Talk Back

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Not-so-new scramjet

Your recent articles on scramjet propulsion [April] and the spaceplane concept [May] were informative and timely, but the developments you describe could have come years ago. A remarkable study by W. H. Avery and G. L. Dugger demonstrating the superiority of the hydrogen-burning ramjet for flight into space appeared in *Aeronautics and Astronautics* in 1964. The Air Force Museum in Dayton, Ohio, has one of the remaining X-15s, together with its final cargo—the first and only flying scramjet prototype. The decision to cancel the X-15 (and the scramjet) in the mid-60s was incredibly shortsighted because no computer or wind tunnel can provide the experience necessary to develop a practical and safe vehicle for flight into space. Also, no one has suggested using the most common method of obtaining multi-stage performance in the spaceplane: in-flight refueling.

Daniel Woodard, M.D., Dayton, Ohio

Comparing apples and oranges

Your article on the Ford Taurus [April] made me mad. You are comparing apples and oranges when you put the top-of-the-line V6 engines against the bottom-of-the-line Dodge four. You say that the 2.2 turbo for the Dodge is too crude to put against the V6s. I find the 2.2 turbo an excellent engine that would have dominated this group of cars.

Joe Walton, Paradise, Calif.

Colder-climate protection

In "Cooler Heads for Hotter Engines" [June], you talk about the benefits of using propylene glycol (boiling point of 369 degrees F) as the coolant in the engine instead of an ethylene glycol/water mixture. But what about the freezing point of propylene glycol? The ability for an engine to withstand cold is as important as its ability to withstand heat if the car is to be operated in a colder climate like Alaska or the Midwest.

Dana M. Lafavour, Juneau, Alaska

Stuart Brown replies: "Straight propylene glycol freezes at minus 71 degrees F, making it an excellent four-season coolant. By comparison, conventional 50 percent ethylene glycol/50 percent water coolant freezes at minus 32 degrees. Straight ethylene glycol freezes at nine degrees at atmospheric pressure."

Torch still off-limits

Your feature on Miss Liberty [June] is excellent. It covers everything except access to the torch. It is my understanding that many years ago the more intrepid visitor could climb a scary steel ladder to the torch. I was hoping this restoration project might lead to the reopening of the torch.

David K. Johnson, Nashua, N.H.

V. Elaine Gilmore replies: "Indeed, you do get to the torch by climbing a narrow ladder inside Lady Liberty's right arm. But according to the National Parks Service (her custodian), there has never been public access to the torch except for an occasional VIP. Sad to say, the restoration will not change that."

The Wright way to fly

In his reply to Who's the Biggest? [RTB, June], Ben Kocivar disqualifies *The Spruce Goose* as the world's largest airplane because he doesn't

Continued

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Small Wonder

It's here, *pocket-size* radar protection.

Imagine a superbly crafted electronic instrument, powerful enough to protect against traffic radar, miniaturized enough to slide into a shirt pocket, beautiful enough to win an international design award.

Small means nearly-invisible protection

That could only be PASSPORT. It has exactly what the discerning driver needs, superheterodyne performance in a package the size of a cassette tape.

This miniaturization is possible only with SMDs (Surface Mounted Devices), micro-electronics common in satellites but unprecedented in radar detectors. It's no surprise that such a superlative design should be greeted by superlatives from the experts.

"In a word, the Passport is a winner," said *Car and Driver.*

The experts report excellent performance. Simply switch PASSPORT on and adjust the volume knob. Upon radar contact, the alert lamp glows and the variable-pulse audio begins a slow warning: "beep" for X band radar, "brap" for K band. Simultaneously a bar graph of Hewlett-Packard LEDs shows radar proximity.

Small means the size of a cassette tape

As you get closer, the pulse quickens and the bar graph lengthens. Should you want to defeat the audible warning during a long radar encounter, a special switch provides silence, yet leaves PASSPORT fully armed for the next encounter. A photocell adjusts alert lamp brightness to the light level in your car. PASSPORT was designed for your protection *and* your convenience.

In PASSPORT, 102 SMDs (right) do the work of ordinary transistors, resistors and capacitors.

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Small means an easy fit in the briefcase

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Readers Talk Back *Continued*

"think it should be ranked with flyable craft." Orville Wright's flight on December 17, 1903, was 12 seconds long and covered about 120 feet. The altitude was about the height of a man. Even though the Wright machine required a catapult coupled with a strong head wind to become airborne, the Smithsonian Institute considered it to be the first flyable craft. Wouldn't it be more fair to categorize the *Goose,* which flew for one minute at an altitude of 70 feet, as the largest nonoperational airplane?

Roger F. George
Altamonte Springs, Fla.

Character count

The item Chinese Word Processor, in May's "Electronics Newsfront," was informative but left me confused. The report says that there are 10,000 unique characters in the Chinese language, but the processor handles 13,000 Chinese characters. Where did the other 3,000 characters come from?

Cuong Nguyen
Huntington Beach, Calif.

Gauss Rescino, marketing manager at Intech Systems, replies: "There are 5,000 to 6,000 frequently used characters that make up the core of the Chinese language. The most exhaustive dictionaries include more than 50,000 characters, many of which are extremely rare. Intech chose 13,000 characters because that's how many could fit into the system."

Rehashing radon risk

In the item Radon—Just a Scare? [RTB, March], V. Elaine Gilmore responds that "the only study of cancer and radon has been done by Dr. Bernard Cohen." This is not true. Epidemiological studies of uranium miners in the 1960s have well established the link between lung cancer and radon exposure. Data from these studies provide a direct estimate of lung-cancer risk to occupants in homes with high radon concentrations (greater than 10 pCi/L), while various extrapolation methods have been used to estimate the risk associated with lower and more usual concentrations.

Francis J. Offermann III
Earth Metrics Inc., Burlingame, Calif.

Foam for outboards

"Lost Foam—A New Way to Cast Car Parts" [April] caught my attention. For the record, Evinrude Motors, a product group of Outboard Marine Corp., has been utilizing lost-foam technology in our manufacturing process for two years. General Motors may be leading the way in the automotive industry for this technology, but Evinrude has been offering the state-of-the-art technology to the American consumer for the past two model years.

Tom Anderson
Evinrude Motors, Milwaukee, Wis.

Toxic to tots?

Regarding Roy Doty's "Wordless Workshop" in June: PVC pipe is very toxic when ingested. Because small children have been known to chew on nearly anything, this may be an unsafe solution to the problem with the wagon.

Joseph E. Miller, Ville Platte, La.

Fred Oehme, staff scientist at the American Academy of Chemical Toxicology, in Manhattan, Kan., says that a child would have to eat about a pound of ground-up PVC to have ill effects, and few children are that voracious.

Backward clocks

I read with interest your June car test, but I am amazed that you can keep abreast of developments in this fast-changing world when your clocks are running backward. I'm referring to the caption on page 28. Also, the Volvo is mentioned as having both disc-drum brakes and "four cold discs." Which is it?

Cameron C. Cox, Pulaski, N.Y.

We stand corrected: The caption should have read "counterclockwise," and the Volvo has four-wheel disc brakes.

Correction

Your rewrite of my letter [RTB, April] completely distorts the intended meaning. I never advocated "getting rid of spark plugs" to avoid the need for higher-octane gasoline. Even the work of Lawrence Berkeley Laboratory's Antoni Oppenheim ["Science Newsfront," Feb.] probably relies on a spark plug to fire the jet igniter, which, in turn, ignites a lean mixture in the cylinder. I do believe it is possible to reduce the need for high-octane gasoline by knock-sensor control of spark advance to individual cylinders. I believe over $30 billion annually could be saved by lowering today's engine octane requirements by about 15 octane numbers.

John A. McDougal, P.E.
Detroit, Mich.

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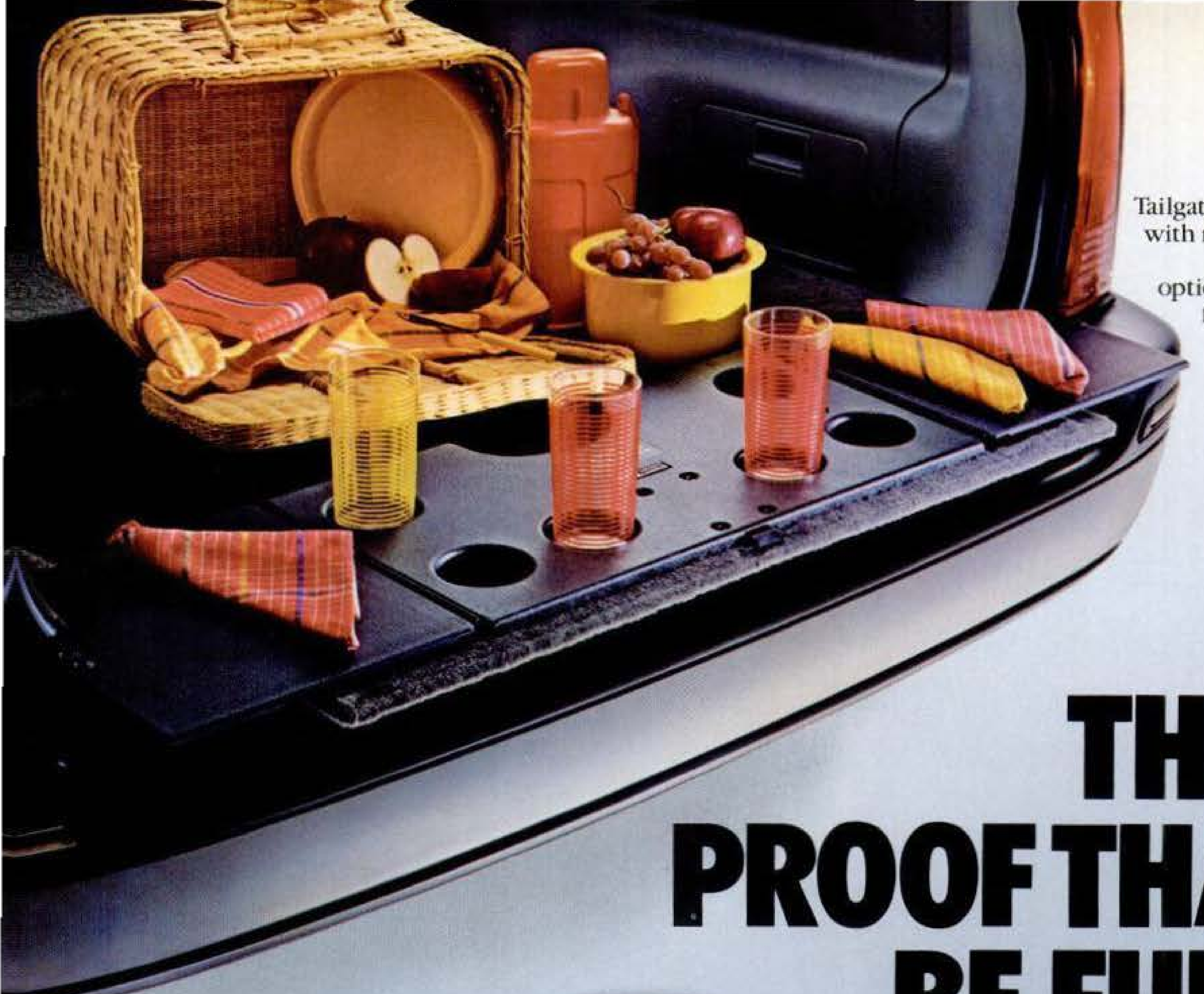


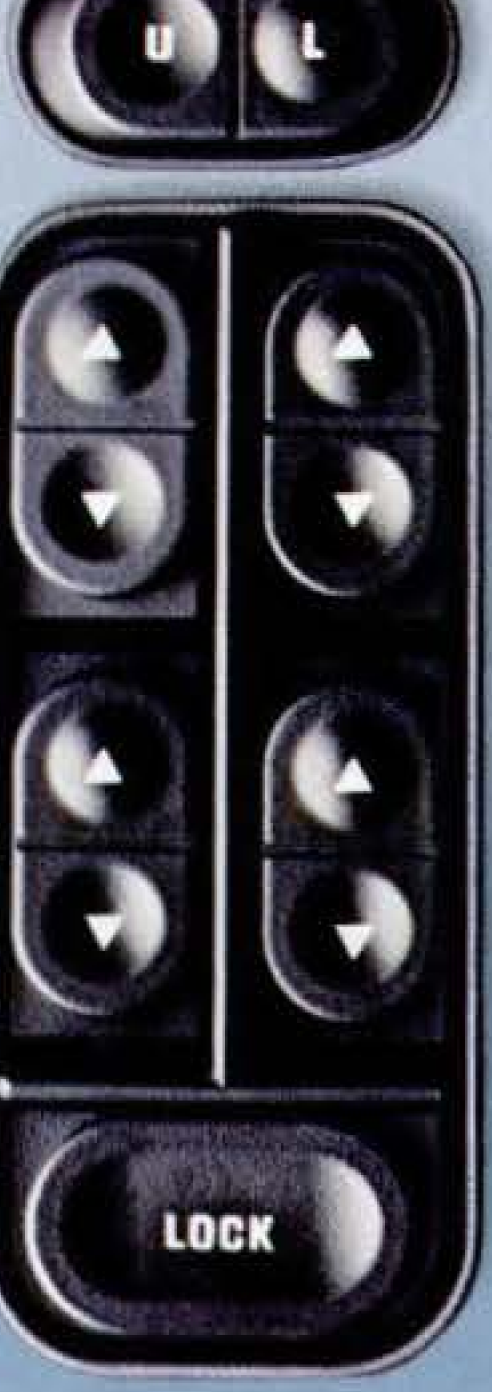
Tailgate parties are popular with many wagon owners. So Ford designed an optional picnic table that folds out of the cargo floor and extends over the bumper.

THE NEW TAU
PROOF THAT A WAG
BE FULL OF CAR

The Taurus Wagon is one of the most wo
thought-out automobiles on the road toda
It's full of advantages. From 81 cubic fee
of cargo space (with the second seat dow
to dozens of features that not only answer
the needs of the driver, but those of the
passengers as well.

The Taurus Wagon.

It's loaded with exceptional thinking.



The tactile controls on the LX are designed so they can be operated by feel, allowing the driver to keep his or her eyes on the road.

Flush fitting glass reduces wind turbulence which means less interior wind noise.

The optional electronic instrument panel is designed to be "user friendly." All instruments are easy to read and all controls are placed where your hands can easily find them.

RUS WAGON.
N DOESN'T HAVE TO
O TO BE LOADED.

The best-built American cars.

At Ford, Quality is Job 1. A 1985 survey established that Ford makes the best-built American cars. This is based on an average of problems reported by owners in a six-month period on 1981-1984 models designed and built in the U.S.

*Based on 1986 EPA Cargo Volume Index.

The illuminated mirror on the passenger side of the LX slides out from inside one of the dual sun visors, so it can be adjusted close to the face.

Have you driven a Ford... lately?

Buckle up—Together we can save lives.

Science Newsfront

By ARTHUR FISHER

Imaging Halley in UV

Halley's Comet streaks toward the sun at right in this false-color enhancement of a photo taken in far-ultraviolet light. At this wavelength, 121.6 nanometers, atomic hydrogen is recorded, and the picture shows an immense cloud of hydrogen atoms that surrounds the comet and extends tens of millions of miles from the nucleus. The elongated tear-drop shape "downwind" of the sun demonstrates the influence of solar radiation pressure on cometary hydrogen atoms.

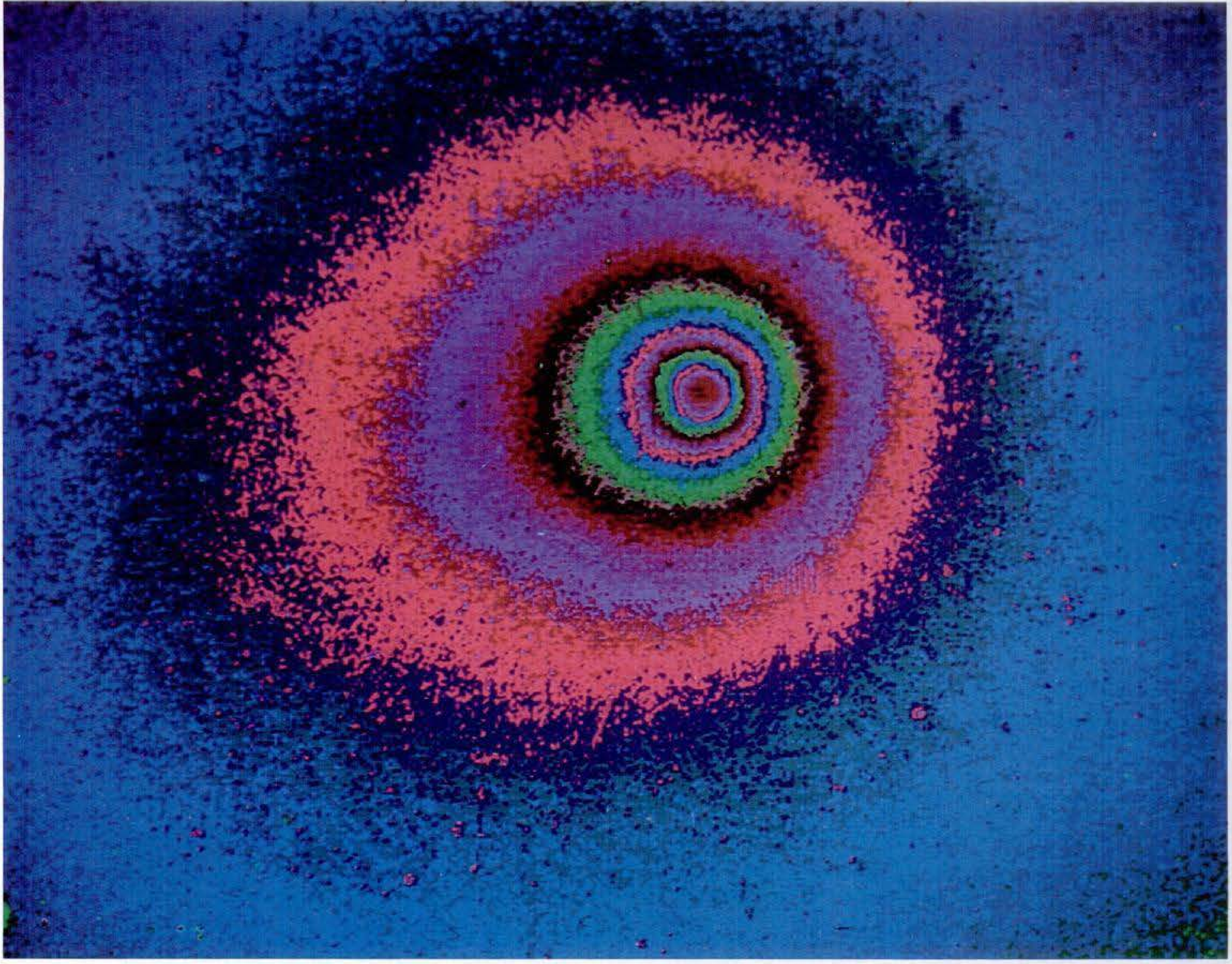
The image was made by an electrographic camera aboard a NASA Black/ Brant Terrier sounding rocket on March 13, under the sponsorship of scientists from the Naval Research Laboratory and the University of Texas at Austin. Fired from the Army's White Sands Missile Range, in New Mexico, the rocket carried twin cameras to a height of 193 miles. This picture was made just 13 hours before the closest approach to Halley's Comet of the European space probe Giotto.

Synthetic bodies

Polymer scientists at the National Bureau of Standards (NBS) have perfected a synthetic material that responds like living human muscle tissue when exposed to the kind of electromagnetic radiation typically emitted by some medical instruments. The organic material will be used by the Food and Drug Administration to study the effects of diathermy and hyperthermia treatments, in which various devices generate electromagnetic radiation to induce heating in body tissues, either for physical therapy or as part of treatment for cancer.

Dr. Martin G. Broadhurst of the NBS turned first to the leaves of the jade plant to obtain basic measurements; he was aware that plant leaves have the same responses as muscle tissue to high-frequency stimulation. Then he and his colleagues formulated the new material to be used as a phantom for the human body. They simulated natural tissue water by a mixture of 50 percent propylene carbonate and 50 percent ethylene carbonate, the same non-evaporating stabilizers used in some cosmetics. For the salt content of living tissue, they added tetraethyl ammonium tetrafluoro borate. And to simulate the effect of cell walls, which inhibit ion transport in living tissue, they added 1.5-micron-thick flakes of polyester

Continued



Computer-enhanced far-ultraviolet photo of Halley's Comet shows a huge cloud of hydrogen atoms that surrounds it.

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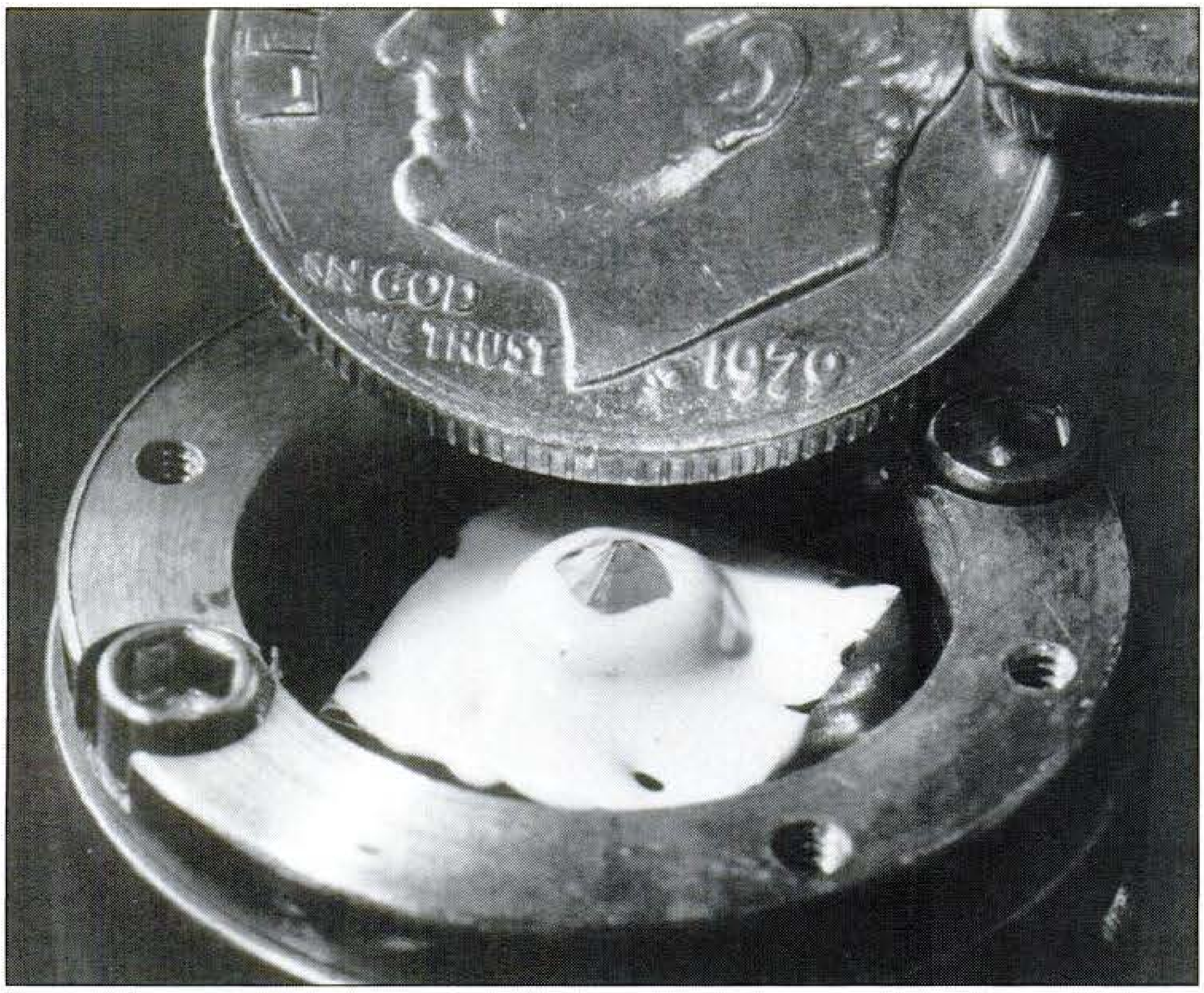

This tiny diamond anvil is used to achieve enormously large crushing pressures.

film. Then they thickened the mixture with fumed silica particles and polyethylene glycol dimethacrylate.

The result, says Broadhurst: "We have tailored our material so that its heat response from electromagnetic waves is the same as natural living tissue."

Paging Dr. Frankenstein.

High-pressure job

Using a device known as a diamond anvil (one half of which is seen in the photo at left), physicists at Cornell University have changed the crystalline structure of the semiconductor element germanium by crushing it at a pressure of 1.25 megabars—1.25 million times normal atmospheric pressure. This is the highest pressure at which changes in crystalline structure have been observed directly—by the technique of X-ray diffraction.

Comparable pressures exist only deep within the planets (estimated 3.5 megabars at Earth's core). At Cornell, a team led by Yogesh K. Vohra and Arthur L. Ruoff achieved this exalted pressure by compressing the germanium sample between the flat faces of two diamonds in the anvil. Diamonds are used, of course, because of their hardness. In the Cornell anvil, the tips of two gem-quality one-third-carat diamonds are ground to flat surfaces only 300 microns (0.012 inch) across.

Chernobyl omens

In the fall of 1978, I joined a group of journalists on a first-ever tour of nuclear reactors and research centers inside the Soviet Union. Recent events at Chernobyl led me to reread my May 1979 Popular Science story of that trip, and to reprint the last part of it here:

It was at Kurchatov [Kurchatov Atomic Energy Institute in the Moscow suburbs] that we saw our first nuclear reactor inside Russia, and it was a startling experience. We were led to a small experimental reactor that had its lid removed so that we could peer down into the pool of water where fuel rods "burned" with the furious blue glow produced by intense radiation. Our guides remained totally nonchalant as we jostled for a better look, pressed against two skimpy railings that were all that kept several of us from a radioactive baptism. Although there was probably no danger from the radiation, shielded as we were by some 15 feet of water, the scene was not one that could be duplicated at any nuclear facility in the Western world.

Kurchatov's director of nuclear safety, Yuri Svinstev, insists that we in the West are too preoccupied with safety matters: "In our estimation, the safety of nuclear plants is much greater than that of any other human activity." He stressed that neither a reactor core melt-down nor a sudden "loss-of-coolant" accident was remotely possible. This belief leads to a reactor design philosophy totally at odds with ours. We insist on a massive, expensive outer containment dome to prevent the spread of radioactive materials in case of just such accidents; the Soviets think the domes are unnecessary.

We saw this schism neatly illustrated in a pair of visits to nuclear power plants, one at Loviisa, Finland, near the Russian border, and the other at Novovoronezh—largest nuclear complex in the Soviet Union—300 miles and a 12-hour train ride south of Moscow, on the River Don. The plant at Loviisa, which the Finns jokingly call "Eastinghouse" because it melds technology from East and West, uses a 440-MW pressurized-water reactor built by the Russians, which is essentially the same as two of the reactors at Novovoronezh. But unlike the Novovoronezh units, which have no containment, the Loviisa reactor is surmounted by a large dome, at the insistence of the Finns. This is the first Soviet reactor to be sold in the West; the Russians have already lost reactor orders in Yugoslavia and Rumania because those countries demanded containment. Astonishingly, we saw a new, 1,000-MW reactor being built at Novovoronezh with *a containment dome [it was the fifth reactor built there; and the first in the Soviet Union to be built with containment]. Plant director Vitaly Sedov grumbled that the order to add it had come direct from Moscow, and that the extra expense, an estimated $30 million, was "a waste of money." The speculation is that the Soviet authorities hope the change at Novovoronezh—a showcase for foreign shoppers—will help sell more reactors in the West.*

When asked about the disposition of radioactive waste and about reprocessing of spent fuel, Mr. Sedov gave less than explicit answers. In fact, he was probably the least helpful—and most surly—of all the Russians we encountered. He did, however, utter what may be the most telling comment of the whole trip. At Novovoronezh, where a wall at the main entrance is emblazoned with the slogan "Let the atom be a worker, not a soldier," he was asked whether there was no undercurrent of resistance to nuclear energy among the public, as there was to a troubling degree in the West. "No," he said, "we told our people it was both safe and desirable, so of course they accepted it."

Of course.

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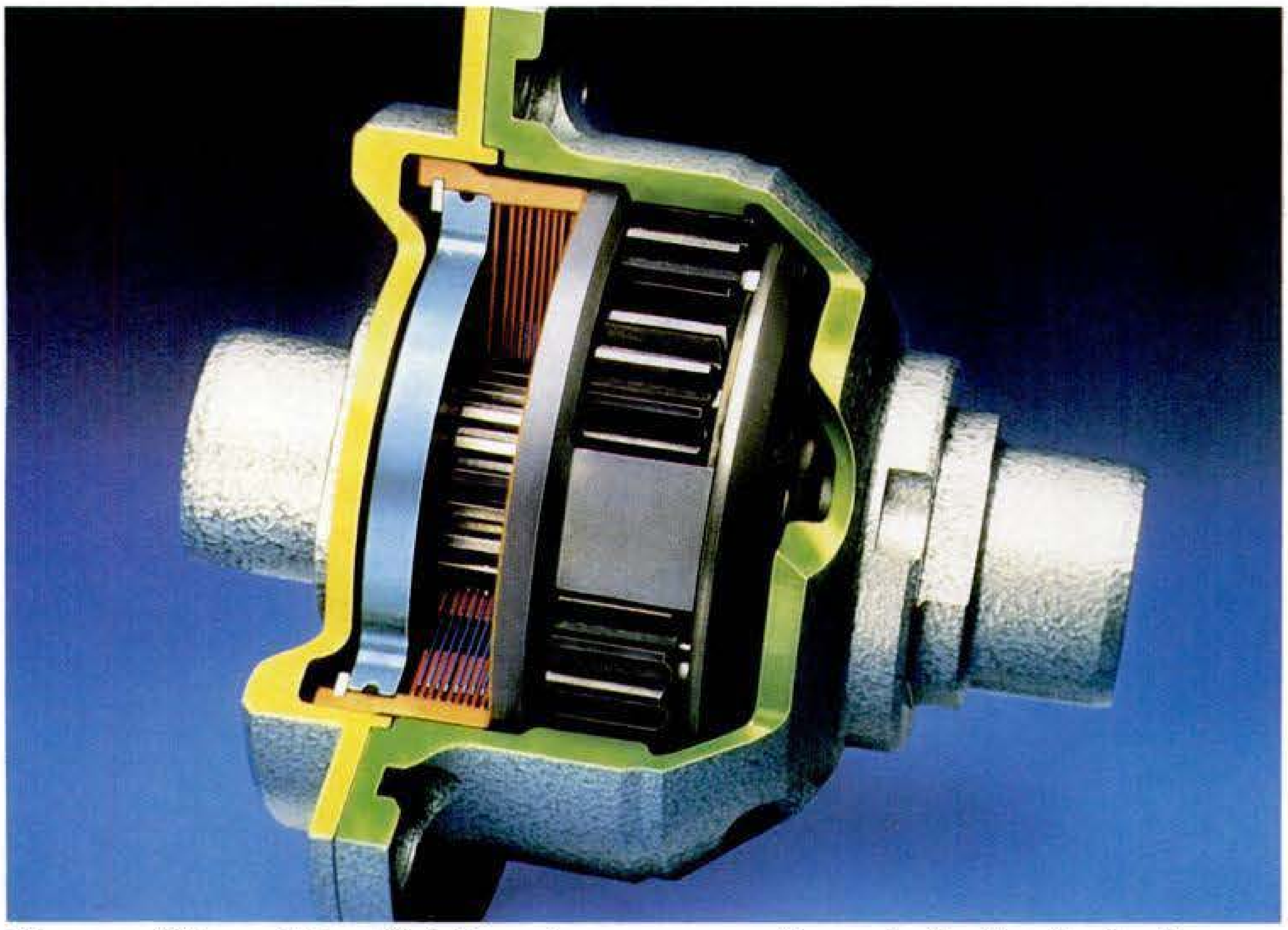
Automotive Newsfront

By DAN McCOSH

Detroit Editor



Viscous differentials will help put more power through the front wheels.

Slippery diff

Among the many things mom said never to try was a full-throttle start in a turbocharged front-drive car while one wheel is in a mud puddle and the other is on dry pavement.

But that's what I did while testing GKN's new viscous limited-slip differential. I popped the clutch of the specially prepared 130-horsepower turbocharged Ford Escort, and sure enough the wet wheel spun. The surprise came as the front wheel on the dry side of the road started to bite, and the car quickly accelerated. (Normal differential action would have sent all the power to the wheel with the least traction, resulting in lots of noise but little forward motion.)

Then, as the car moved ahead, the spinning wheel hit the dry surface. In most front-drive cars, this would have caused a sideways leap. But in this Escort, there was nary a twitch of the steering wheel. Just as I was learning to anticipate the quirks of high-horsepower front-wheel-drive cars, GKN has changed things around.

Front drive has a number of benefits, including improved interior room and better traction in slippery conditions. But it has drawbacks as well. Much of what you need to get high horsepower on the road is all wrong with front-wheel drive.

First, weight transfer under hard acceleration unloads the driving wheels. With the wheels lightly loaded, a high-torque power plant can then make one wheel grab, then the other, starting a scrabbling action like a cat climbing up the drapes. Also, acceleration out of a corner unloads the inside front wheel, severely limiting the power the car can put to the ground.

Careful attention to suspension geometry and drive-line design can lessen these evils. Now, the U.S. subsidiary of Britain's GKN PLC, the largest supplier of front drive shafts, is offering another solution.

GKN's system is a variation on the limited-slip differential offered today on many rear-drive cars. But most systems on the market now use dry clutches to lock the differential when one wheel begins to slip, and the locking action would be too abrupt for front-drive cars.

GKN couples the two sides of the differential with a series of plates running in thick silicone fluid. As a demonstration, GKN engineer Mark Willett, viscous-drive project manager, handed me a glassful of the fluid with a spoon stuck in it. When I turned the glass over, the liquid was so thick that the spoon stayed firmly in place.

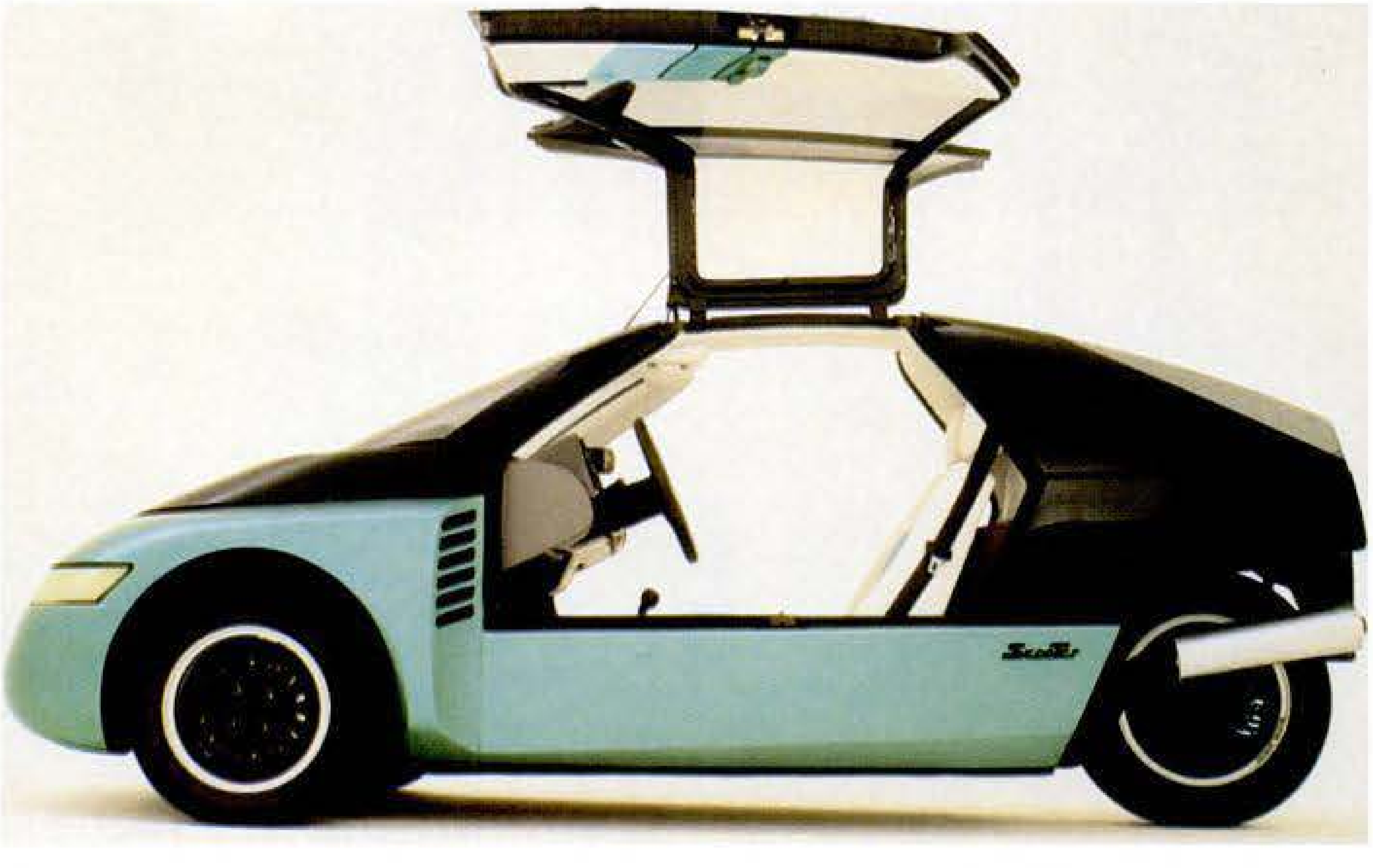
This stickiness is enough to transmit considerable torque, but it still allows enough slip to make the unit very smooth. Silicone also thins little as it heats up, important in keeping the unit operating at high loads.

The viscous-coupling principle already is used in center differentials for some four-wheel-drive vehicles. These allow enough slip between front and rear axles to keep the drive line from binding on tight turns, and make it possible to keep four-wheel drive engaged full time. Now it looks as if viscous differentials soon will start to appear on front-drive cars as well.

Last year, Ford of Europe introduced a turbocharged rally car with a viscous-clutch limited-slip. But so far other European manufacturers haven't followed suit. The earliest application on U.S. cars will likely be on the 1990 Firebird and Camaro, when those cars go from rear- to front-wheel drive.

On the test car I drove, hard cor-

Continued



VW Scooter has two seats, three wheels, and a briefcase in the dash.

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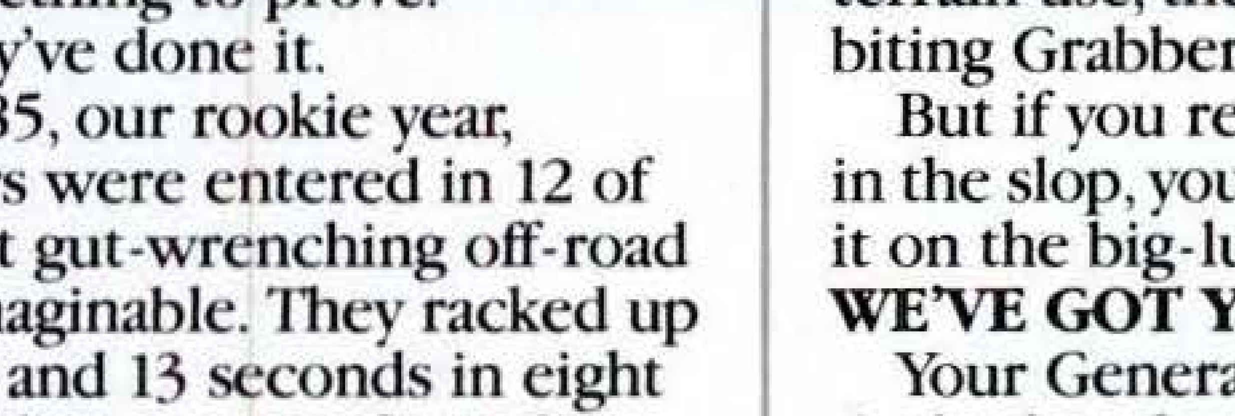

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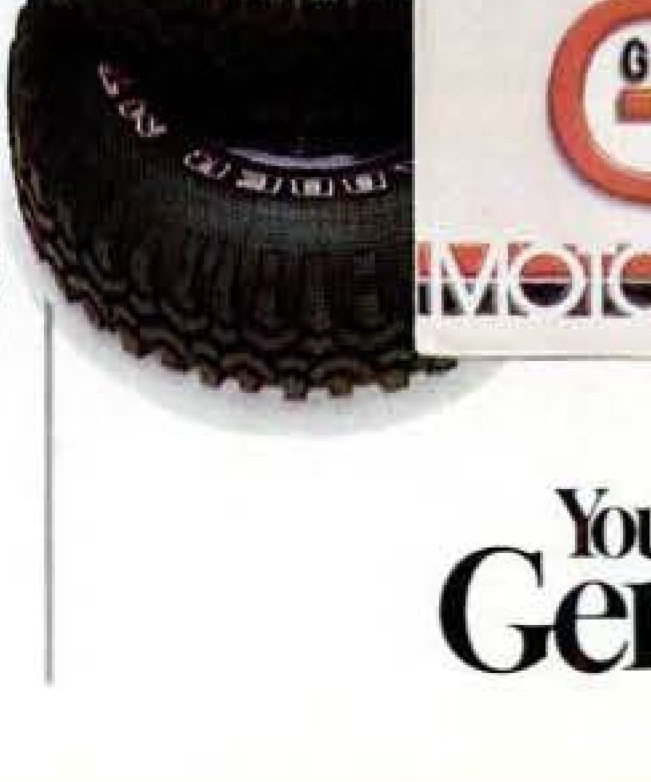

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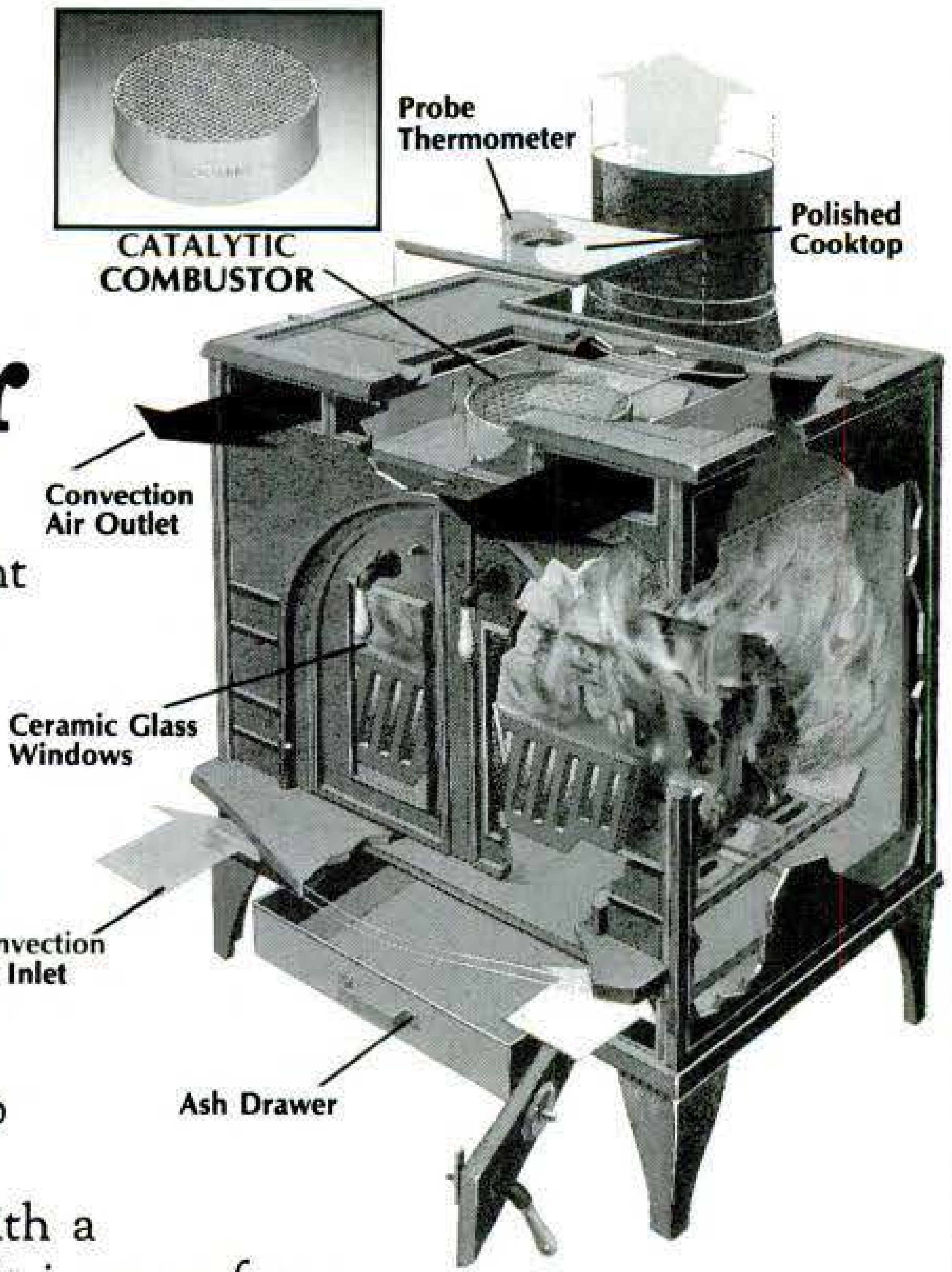

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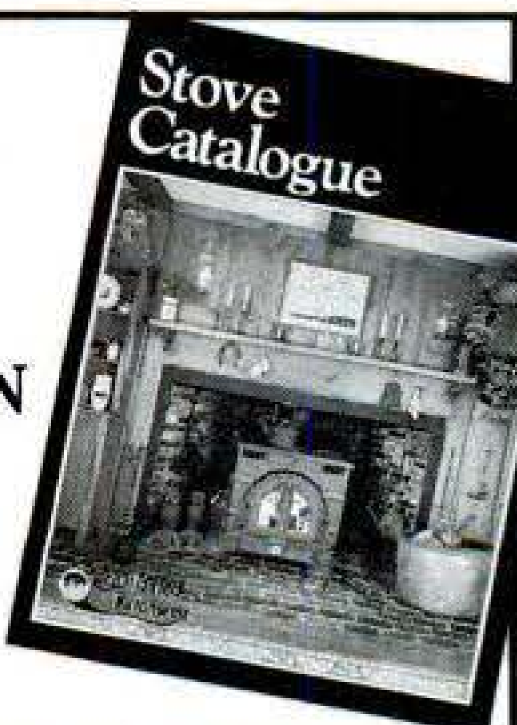

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1987 Thunderbird turbo: Son of SVO may have a top speed of 140 mph plus.

nering revealed few quirks. The added traction reduced power understeer coming out of corners, and acceleration was extremely good, even when the inside wheel was unloaded in a sharp turn. Most noticeable was the lack of any abrupt transitions as the differential did its job. Two other GKN test cars equipped with viscous-drive systems—a rear-drive Mustang and four-wheel-drive Opel Senator with sticky couplings front, rear, and center—also were so smooth that it was difficult to tell when the system was working.

Simple as the principle is, the viscous limited-slip has taken considerable development work. Willett said that a major problem was a phenomenon he called "humping."

When humping occurs, the viscous drive suddenly multiplies the torque it is transmitting. "It effectively locks up," Willett said. Sometimes this is beneficial, as when the differential is transmitting torque between front and rear axles of a four-wheel-drive car. But on a front-drive car, it could cause torque steer.

"We don't completely understand the phenomenon," said Willett. "But we can design a differential to either eliminate humping under normal use, or to use it to our advantage."

Son of SVO

The Popular Science spy camera just grabbed this shot of the 1987 turbo Thunderbird, which shows the grilleless look that will become more and more popular in future years. The new 'Bird will incorporate much of the engine and suspension technology developed for the SVO Mustang, a car that will be dropped from the Ford lineup.

Three wheels better?

Volkswagen's latest exercise in minimalism is an egg-shaped concept car/motorcycle, called the Scooter. It weds the basic four-cylinder VW power train to a two-seat body with a single oversized wheel in back.

Said to combine the best of passenger cars and motorcycles, the Scooter uses a slick exterior surface to bring the drag coefficient down to 0.25. For open-air motoring, the two gull-wing doors and rear window can be removed. Luggage space is tight, though—a removable attaché case that fits into a compartment on the instrument panel doubles as a glove box.

Bang, bang—you're alive

Following the lead of Mercedes-Benz, Saab will equip its 9000 Turbo models with automatic seat-belt tensioners. In case of a head-on crash of more than 11 mph, a small charge similar to a shotgun shell fires, forcing a piston up a cylinder. The piston pulls a wire attached to the seat-belt takeup reel, snapping the belt tight.

Saab says tests with instrumented dummies show that the tensioners can improve survivability in a collision by 50 percent.

Chrysler, Fiat talk

Chrysler continues to look throughout the world for new sources of small cars. One of the most interesting rumors to surface recently is a potential deal with Italy's Fiat S.p.A., whereby Chrysler would sell Fiats here, and Fiat would distribute certain Chrysler products in Europe.

Although talks are only preliminary and Chrysler won't comment officially, company insiders say Chrysler is interested in importing Fiat's subcompact Uno, and in selling mini-vans overseas. More important, a joint venture with Fiat would likely include Chrysler's upcoming Liberty project, a new series of platforms due three years from now that include a sedan and a van smaller than the current Voyager/Caravan. Fiat's expertise in low-cost automated production could benefit Liberty.

High-tech tractor

Honda has unveiled a vehicle using the rear-wheel steering system it's developing for passenger cars [ANF, PS, July]. But it's not an exotic sports machine. Rather, it's a garden tractor.

The heart of the system is a mechanical linkage that allows the rear wheels to steer with the front at low steering angles, then switches to allow them to steer in the opposite direction for sharp turns. Honda claims the system gives the tractor enhanced stability, the same benefit sought for sports cars. But this time the goal is nice, neat furrows.

Expanding Dakota

Even as the new Dodge Dakota goes on sale, plans are afoot to broaden its appeal. At the launch of its Dodge City—a huge Detroit-area complex built to produce the new truck—Chrysler officials revealed that a four-wheel-drive version will be available by midyear, most likely to be followed by an extended-cab Dakota. Then comes a mid-size Ramcharger-style utility version.

Executives at Ford, meanwhile, confirm that the next change in the Aerostar mini-van will be the addition of four-wheel drive, most likely in 1988. Chrysler also has been testing a 4×4 mini-van, but hasn't committed to a production program.

News briefs

- Toyota has broken ground for an $800 million car plant in Scott County, Ky. To be completed by mid-1988, the factory will produce 200,000 Camry-class cars per year for sale in the U.S.
- Add one more thing to the used-car checklist. The Motor Vehicle Manufacturers Assn. says used-car buyers should peek under the car and make sure the catalytic converter is still in place. Emissions inspections in many areas now include a visual check of emissions components. Not having a converter could mean spending hundreds of dollars for a replacement.
- It now appears certain that a stretched version of the Chrysler mini-van will go on sale in 1987. Look also for the long-rumored Mitsubishi V6, which should give the Voyager and Caravan some extra oomph.

Contributors: Jack Keebler, Tom Wilkinson (New York)

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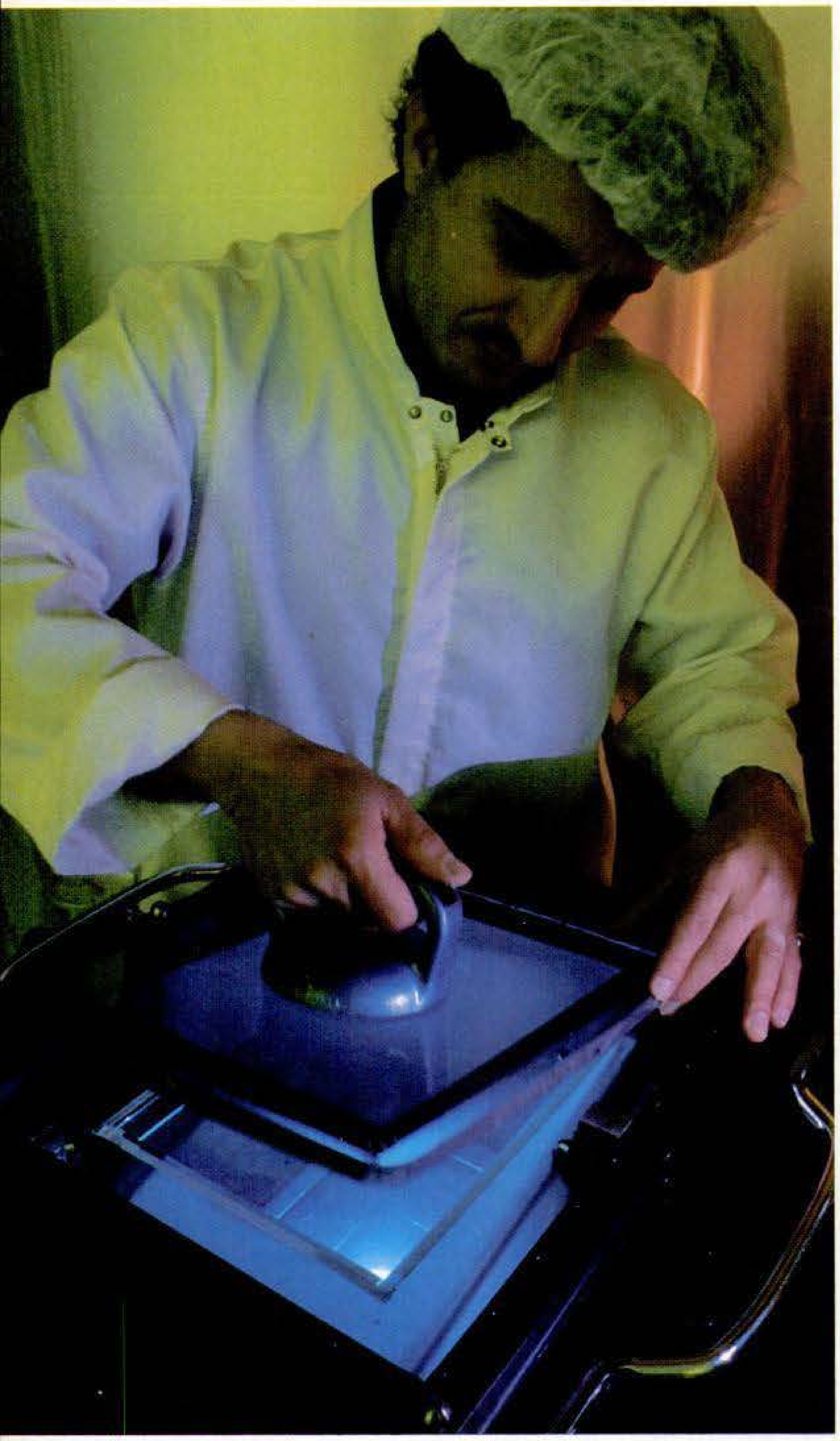
Flat-face tubes
—crisp new look for computers, TVs

Metal shadow masks, a key component in color picture tubes, are stretched taut with Zenith's new technique, which prevents heat warpage and degraded images. The result: a new performance high for computer screens and TV pictures.



A worker lifts a flat phosphor-coated faceplate from a light table at Zenith to make an advanced new tube. Photographic techniques establish the correct sites for phosphor dots on the panel. Newly developed manufacturing technology employs a glass backup (B) ring to hold a flat shadow mask under high tension just behind the faceplate (right). Registry features—small ceramic beads—fit in depressions to ensure that the B ring, panel, and funnel align precisely.

By JOHN FREE

GLENVIEW, ILL.

As I approach two video monitors at Zenith Electronic Corp.'s research center here, images on both screens—colorful computer-graphic displays—appear equally bright. But one picture, on a new type of Zenith tube, seems to float on a coal-black background. The adjacent image, on a popular $1,200 high-resolution monitor, has annoying reflections—despite dim lighting in the demonstration room.

"Now watch what happens when I turn this on," says Wayne Chiodi, director of display-device research and development, switching on a nearby floodlight. As I squint through the intense glare, the picture on the $1,200 monitor almost vanishes in the strong screen reflections. But remarkably, the image on the Zenith tube hasn't changed: Its glare-free background seems to soak up ambient light,

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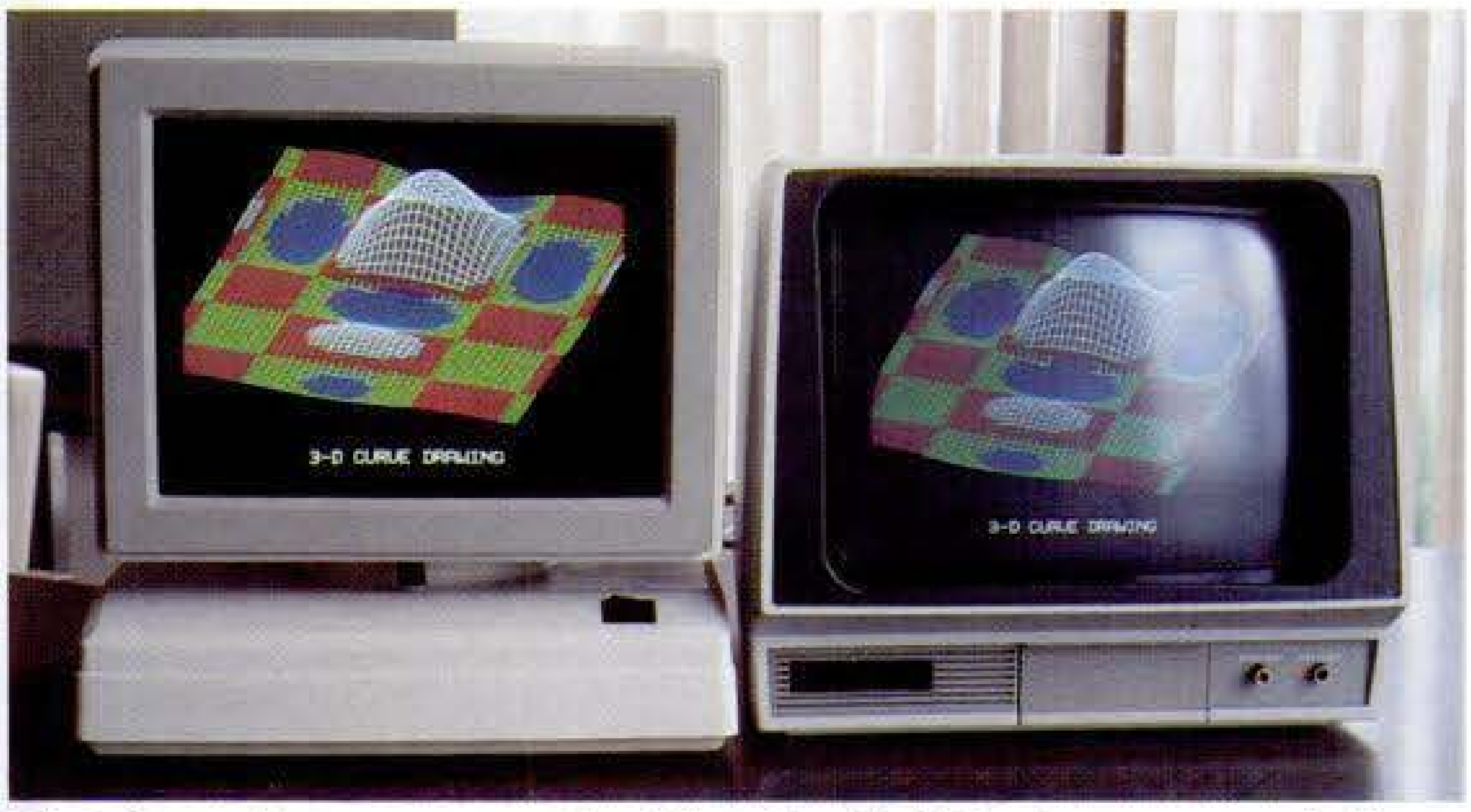
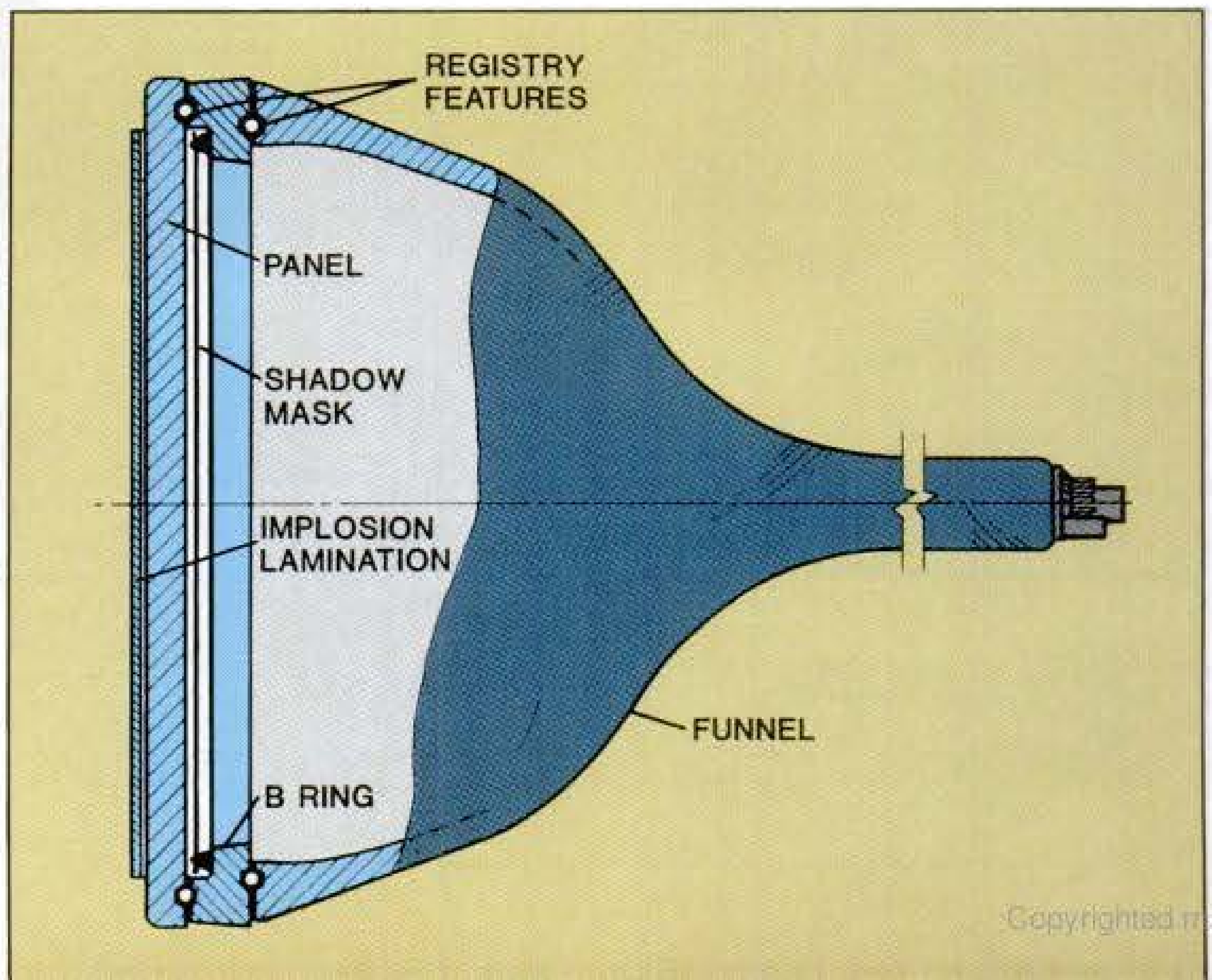


Flat faceplate on new Zenith tube (left) helps prevent glare prominent on ordinary tubes (right) that have curved surfaces. Dark filtering in Zenith's tube helps cut reflections.



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as if into an astronomical black hole.

This dramatic display improvement is the result of new technology for making cathode ray tubes (CRTs). Its new picture tube, says Zenith, can be driven much harder than ordinary designs, for up to 80 percent more brightness or up to 70 percent better contrast. Enhanced-contrast screen images appear crisper and more detailed. And the mirror-flat face on the new tubes minimizes glare.

The tube is slated only for computer monitors at first. But eventually home TVs should benefit, too. Says Karl Horn, president of Zenith's Systems and Components Group: "This is the beginning of the next generation of cathode ray tubes."

In his office, Chiodi demonstrates how the new CRT differs from conventional designs. In most color tubes, three electron beams sweep back and forth across a metal screen called a shadow mask. This mask, just behind the viewing faceplate, is perforated with thousands of tiny holes. In front of each hole, on the faceplate, is a cluster of red, green, and blue phosphor dots. Each cluster produces one point of light; color and intensity are controlled by the three beams passing though each hole. The shadow mask ensures that the green beam, for example, strikes only green phosphors, because the two other phosphor colors lie in the mask's "shadow." (Tubes with slotted masks or just vertical slits function similarly.)

Curved mask

Chiodi hands me the rectangular shadow mask for a 13-inch color TV set. The mask, made with six-mil (0.006-inch-thick) rolled steel, is enclosed in a thick metal frame. As I tap the gray sheet, it flexes and rumbles like metal ductwork. "Notice it's spherically shaped," says Chiodi, indicating the mask's slight curvature. During assembly, the glass front panel containing the mask is bonded onto the pyramid-shaped funnel section.

Such shadow-mask tubes, although used almost universally for color, have a significant limitation: As electron beams strike the mask, it heats and expands. "When it moves, the mask holes aren't in the right place anymore with respect to the phosphors," Chiodi explains. Too much brightness overheats the mask, and unwanted colors appear. Chiodi flicks metal strips bonded to three sides of the conventional 13-inch mask before us. "These bimetal springs expand and try to compensate for the mask heating up, but you can compensate only so much," he says. For standard TV images, which lack fine detail, this mechanical compensation is adequate. "When you go to very fine resolution, though, you see its limitations," Chiodi says.

In the early 1980s, these limitations became apparent to Zenith engineers as they studied ways of improving display tubes. One experiment, performed a decade earlier by their colleague, Kaz Palac, seemed promising: In his lab, Palac stretched a foil-like, one-mil-thick steel mask flat over the open end of a CRT faceplate. He sealed the faceplate to the picture-tube funnel section with low-temperature "solder glass." Heated to about 780 degrees F, this glass liquefies, then hardens.

Palac made an important discovery after his modified CRT cooled to room temperature. Because the glass and the metal mask cooled at different rates, the mask had become drumhead tight. Tests showed that the mask tension could minimize the minute movements that can ruin high-resolution displays. Zenith, however, shelved further research. In the early 1970s, no major market existed for computer-grade color CRTs.

But today, with demand growing for computer displays, Zenith engineers have turned that crude mask-tensioning experiment into a patented mass-production technology. "Take a look at this," Chiodi says, handing me a thick glass frame with a foil mask taut between its edges. "This mask is stretched at some 40,000 pounds per square inch," he says. "When you put beam power on it and it starts expanding, there's enough tension so no hole will move from its preferred location."

Blacker blacks

Translated into performance, that means Zenith's flat-tension-mask CRT typically can handle eight times more power than spherical-mask tubes. In displays I saw, Zenith sacrificed this extra brightness to improve contrast by using extra-dark screen filtering. Such filters reduce ambient light reaching screen phosphors, making dark areas in images appear blacker.

The advantage of superior contrast seemed especially striking as I viewed off-the-air TV on a standard receiver modified with a flat-tension-mask tube. On Zenith's new CRT, I often saw details—highlights in clothing or hair, for example—that did not appear on the conventional CRT beside it. The highlights produced more-realistic images.

Zenith has started a pilot production line for deliveries of its new tube next year. Engineers predict many changes in the manufacturing technology. Says Chiodi: "Conventional tubes have had thirty years of optimization. We're just getting started." PS

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Mantis' tines are warranted *for life* against *ever* breaking and its engine has a *lifetime* Replacement Agreement!

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Save Gas, Save Engine with 'POLY'

The following introduces one of the most fully tested and credentialed gas saving, friction reducing engine treatments ever to reach the market!

WHAT IS POLY? "Poly" is short for polytetrafluoroethylene (TFE). It is the slipperiest substance known to man **(1981 Guiness Book of World Records, p. 188).** The PetroLon Corporation, makers of Slick 50, has invented a way to permanently bind this slippery chemical to your engine with one treatment. All you do is add one quart of Slick 50 to your oil during oil and filter change. By reducing engine friction, Slick 50 increases gas mileage and horsepower and reduces engine operating temperature thus causing your oil and engine to last longer. Just as important, it reduces metal wear, defraying costly overhauls.

HOW DO I KNOW THIS ISN'T A FRAUD? Slick 50 has some very impressive credentials. The **"Consumers Digest"** magazine (March/April 1982, p. 35) states "Slick 50 does reduce engine heat and ordinary wear, and our informal tests indicate that it will improve gas mileage by about two or three miles per gallon.... Slick 50 does exactly what Petrolon claims it does." Researchers at a **nationally respected research laboratory**, after applying a powerful ultrasonic cleaning process to a Slick 50 treated engine part, were surprised at its permanence. They stated, "We actually expected the PetroLon Slick 50 TFE Resin coating to also be removed, but later found it was still there."

The **Federal Aviation Administration** has fully accepted a similar product- Slick 50 Aircraft Treatment (F.A.R. #33.49). An FAA test simulating 1400 hours of engine use (equivalent to about 70,000 miles on a car) showed almost zero engine wear!

"Dune Buggies and Hot VW's" magazine, April 1983, p. 70-71, records the results of their one year testing of Slick 50. "We can indeed say scientifically that Slick 50 does work and that it does reduce engine wear!.... for the price of one treatment when compared to engine rebuild, we feel you'd be money ahead using Slick 50." The senior engineering researcher at the **University of Southern California** in San Diego stated this, "Slick 50 does increase horsepower and decreases fuel consumption in tests done at the university." The **Space Shuttle Columbia** uses the chemical "poly" in its gears and bearings because it is the only chemical lubricant which can withstand the heat and corrosive elements of space.

Perhaps the most dramatic of all is a torture-test overseen by the **Automotive Services Council for Pennsylvania** and shown on television station WTVE. Three cars with between 75,000 and 129,000 miles on them were treated with Slick 50. Six months later the oil was drained from each vehicle and the cars were driven without the oil plugs for about a half hour. The water temperature never rose and the engines sustained no apparent damage. There are many more tests available. If you are still skeptical, send $2.00 to defray printing and postage costs and we will send you additional, more detailed, test information, etc.

HOW DO YOU TREAT AN ENGINE? Very simply. Just before oil and filter change, add engine flush (sent free with each order) to clean out your engine. Let your engine idle for 5 minutes. Then drain your oil, change filter and add the proper amount of oil less one quart. Add one quart Slick 50, drive for 30 minutes, and leave it in the crankcase for 3,000 miles. As the engine operates, the oil carries the "poly" between the parts where it is burnished into the pores of the metal. Once impregnated it is permanent, so **you do it only once**, not each time you change oil. One quart of Slick 50 will treat all standard 4, 6 and 8 cylinder gasoline and diesel engines.

WILL IT WORK WITH MOST OIL? Yes, Slick 50 will work with all petroleum based oils and all synthetics compatable with petroleum based oils.

WHAT ARE THE BENEFITS OF SLICK 50? Your actual benefits in percentages may vary, depending on the kind of driving you do, vehicle condition, etc. By reducing friction, Slick 50 does all of the following: it **increases gas mileage**. It **increases horsepower** -- small economy cars and large RV's really need this. It makes for **easier starting** (important in cold weather). It **reduces operating temperatures**, thus increasing the lubrication and life of your oil and your engine. Since lubricating lead is being removed from gas and unleaded gas is poor in lubricating qualities, the **extra lubrication of Slick 50 on valve stems and guides is very valuable**. Last, but not least, the drastic reduction in engine wear **defrays or eliminates costly overhauls** which can save you over $1,000. Slick 50 eliminates the "lubrication starvation" that all cars experience when first started before the oil has a chance to circulate. Up to 90% of the wear on a car can be caused by this lubrication starvation. You receive all of these benefits for **less than the cost of two tanks of gas** ($39.95).

WILL SLICK 50 HARM MY ENGINE OR AFFECT MY WARRANTY? No! Slick 50 is suspended in an excellent grade of petroleum oil which meets or exceeds every manufacturers engine warranty requirements. In addition, this oil carries an API (American Petroleum Institute) service classification SF-CC-CD.

DEALERSHIPS ARE AVAILABLE.

OTHER SLICK 50 PRODUCTS available are Gear Treatment (manual transmission, etc.), 2-Cycle Engine Treatment, Grease, Ultra 9 Oil, Fuel Conditioner, and Fabric Protector. Free information is sent upon request.

EASY TOLL FREE NUMBER. Since Slick 50 is **"too too Slick"** for engine friction, our toll free number is 1-800-22-SLICK (that is, 1-800-227-5425).

Free engine flush sent with each order. Free shipping with orders of 2 or more.

For purchase or further information call toll free 1-800-22-SLICK, (in Colorado, call 1-303-667-1715) or send to: FORT MORGAN SLICK 50, 407 Del Rio Road, Berthoud, Colorado 80513.

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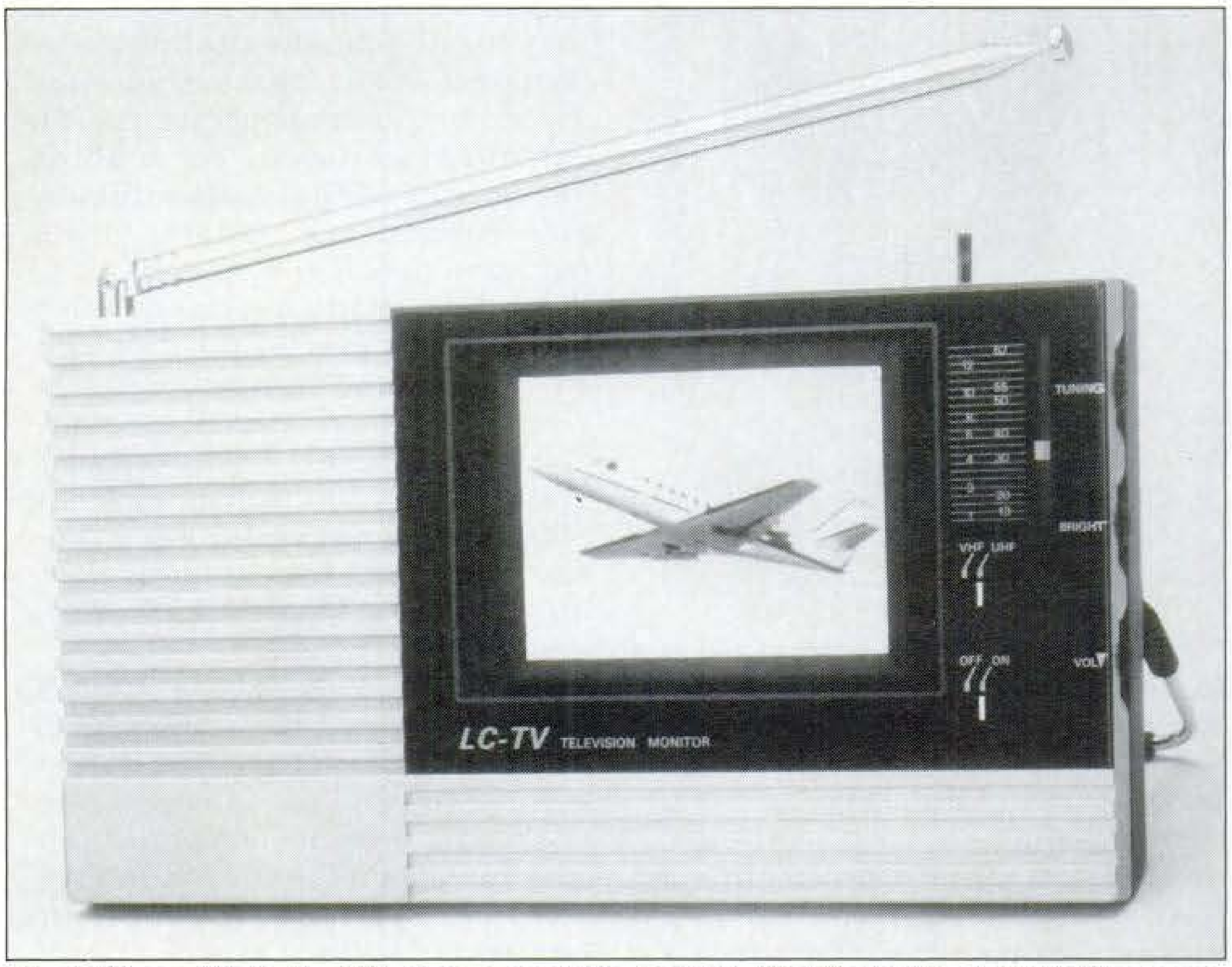
Electronics Newsfront

By WILLIAM J. HAWKINS



The Citizen Stick Up TV uses a passive-matrix 46,720-pixel-array LCD screen.

Hang-on-the-wall TV

"We call it a Stick Up," says John Witt, vice president of marketing for the consumer electronics group of Citizen Watch Co. "It's not designed for portable use. It's an indoor TV set."

Hang-on-the-wall television has arrived. No, the first set is not the 10- to 15-inch screen size that has been predicted for some time [PS, July '85], but a 3.5-inch model, shown above at half size. Made by Citizen, the black-and-white Stick Up looks similar to other LCD TVs, but inside it's designed for semi-permanent installation.

"It's perfect for the kitchen, where space is tight," says Witt. "Just stick it to the refrigerator. Or it mounts on your office wall, in the bathroom, and on the back seat of your car." How does it stick up? "We supply Velcro fastening strips with it," says Witt.

A clever marketing idea? Sure. But to make the Stick Up practical for indoor use, Citizen concentrated on a new backlighting design. "Conventional backlighting consumed too much energy to make long-time viewing practical," says Witt. Citizen uses a new electroluminescent backlighting panel with a power controller circuit. "The circuit uses a step-up transformer to increase the voltage from its C batteries," he explains. "And for efficiency it's controlled by an integrated-circuit chip." The chip limits the amount of power consumed by the panel and ensures that power is drawn smoothly. Result: up to 20 hours of continuous viewing time on one set of batteries.

Although 20 hours may be about twice the viewing time of other models, it's not enough to make you throw away the den TV. But the Stick Up is not a replacement for present sets. "That's the point," says Witt. "Stick Ups are made to go where no other TVs have been used." The 16-ounce set is 1.3 by 4.6 by 8.6 inches and will cost $150.

Personal supercomputer

"Imagine having 500 IBM AT computers in the room with you," says Jeffrey Simon, marketing manager for Culler Scientific Systems. "That's the power of the PSC." The PSC—personal supercomputer—fits easily under a desk, yet it's designed to use supercomputer software and perform 18 million instructions per second.

"That's about one-quarter the speed of a Cray 1-S supercomputer," says Simon. But compared with the $4 million Cray, the $100,000 Culler PSC is a real bargain. "And because it can be shared by 16 work stations," he adds, "the individual user cost makes it practical for small-scale scientific and engineering offices."

Made by Culler Scientific Systems Corp. (100 Burns Pl., Santa Barbara, Calif. 93117), the PSC is a new product category, just below the $250,000 (and more) mini-supercomputers now available.

Pocket consultant

Pocket calculators have just taken a leap forward: Hewlett-Packard's Business Consultant is a programmable calculator that uses your words (profit, price, net cost) in formulas you enter for solving problems in finance, business, and statistics.

"It can be personalized for any application," said Carmen West, manager of hand-held products, as she held it up for me to see. My name, address, phone number, and the time of our meeting appeared on its four-line, 23-character LCD display. "It's even an appointment reminder."

The hinged case opens to expose two keyboards—one for numbers, the other for characters—for quick and easy data entry. Price: $175.

Continued

Culler supercomputer fits under a desk and uses Sun work stations.

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341677. Schubert: Symphonies Nos. 2 & 8. Barenboim, Berlin Phil. (*Digital*-CBS Masterworks)

342592. Motown R&B Grammy Performances Of The 60's and 70's (Motown)

324822. Ravel: Bolero; Rhapsodie Espagnole; etc. Maazel, Orch. de France (*Digital*—CBS Masterworks)

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319541. Elton John—Greatest Hits. *Daniel; Crocodile Rock;* more. (MCA)

343335. Julian Lennon—The Secret Value Of Daydreaming. (Atlantic)

340323. Sade—Promise. #1 Smash. (Portrait)

263293. Bolling: Suite For Flute & Jazz Piano—Rampal, Bolling (Columbia)

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323261. Lionel Richie—Can't Slow Down. *All Night Long; Stuck On You; Hello;* etc. (Motown)

335547. Berlioz: Symphonie Fantastique. Barenboim, Berlin Phil. (*Digital*-CBS Masterworks)

331264. Bryan Adams—Reckless. #1 hit: *Heaven; Run To You;* etc. (A&M)

339903. The Cars—Greatest Hits. *Tonight She Comes;* more. (Elektra)

341263. Enoch Light & The Light Brigade—Big Bands Of The Thirties. *Begin The Beguine;* more. (Project 3)

322008. Linda Ronstadt & The Nelson Riddle Orch.— What's New. (Asylum)

341073. Steely Dan—A Decade of Steely Dan. *Reeling In The Years; Hey Nineteen;* more. (MCA)

320499. The Police—Synchronicity. Winner of 3 Grammy Awards! (A&M)

343160. Beethoven: Symphony No. 9 (Choral). Bruno Walter, Columbia Sym. (CBS Masterworks)

337279. Placido Domingo—Save Your Nights For Me. Love songs. (CBS)

318089. Michael Jackson —Thriller. *Billy Jean; The Girl Is Mine;* etc. (Epic)

342105. Bangles—Different Light. *Manic Monday;* more. (Columbia)

322024. Huey Lewis & The News—Sports. *Bad Is Bad;* etc. (Chrysalis)

314443. Neil Diamond's 12 Greatest Hits, Vol. 2. *You Don't Bring Me Flowers* (with Barbra Streisand); etc. (Columbia)

343624. Wynton Marsalis Plays Trumpet Concertos. Haydn, Hummel, L. Mozart. (*Digital* —CBS Masterworks)

308049-398040. Creedence Clearwater Revival Featuring John Fogerty/Chronicle. Greatest hits. (Counts as 2—Fantasy)

219477. Simon & Garfunkel's Greatest Hits. *El Condor Pasa; Bridge Over Troubled Waters;* etc. (Columbia)

333112. Andreas Vollenweider—White Winds. The inventive harpist's latest (*Digital* CBS)

331645. Madonna—Like A Virgin. #1 album & hits *Material Girl; Angel.* (Sire)

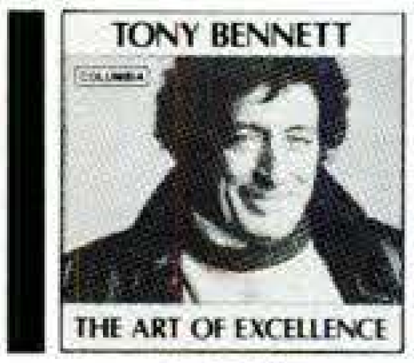
328435. Prince And The Revolution—Purple Rain. #1 hit: *When Doves Cry.* (Warner Bros.)

316604. Tchaikovsky: 1812 Overture; Marche Slave; Beethoven: Wellington's Victory. Lorin Maazel, Vienna Phil. (*Digital*-CBS Masterworks)

342097. Barbra Streisand—The Broadway Album. *Somewhere; Something's Coming;* more. (Columbia)

343715. Vivaldi—Four Seasons. Maazel, members Orch. National de France (*Digital*–CBS Masterworks)

343251. Bach: Goldberg Variations—Glenn Gould (*Digital*-CBS Masterworks)



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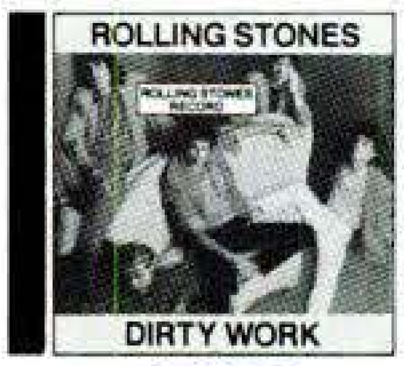

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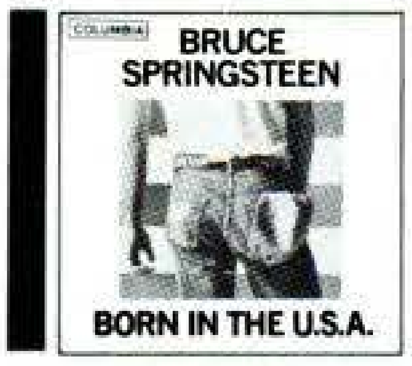

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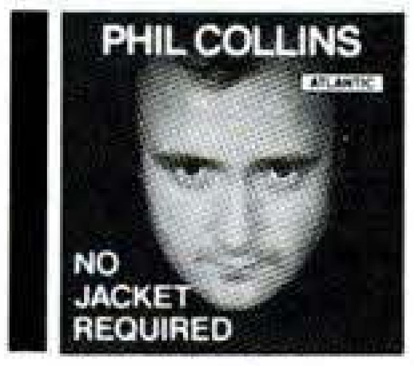

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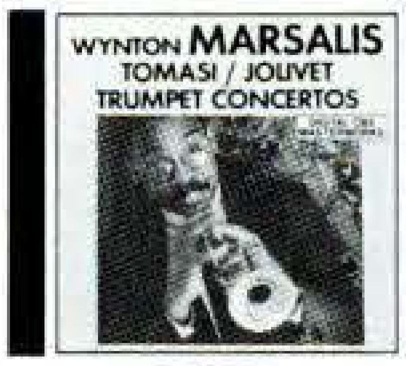

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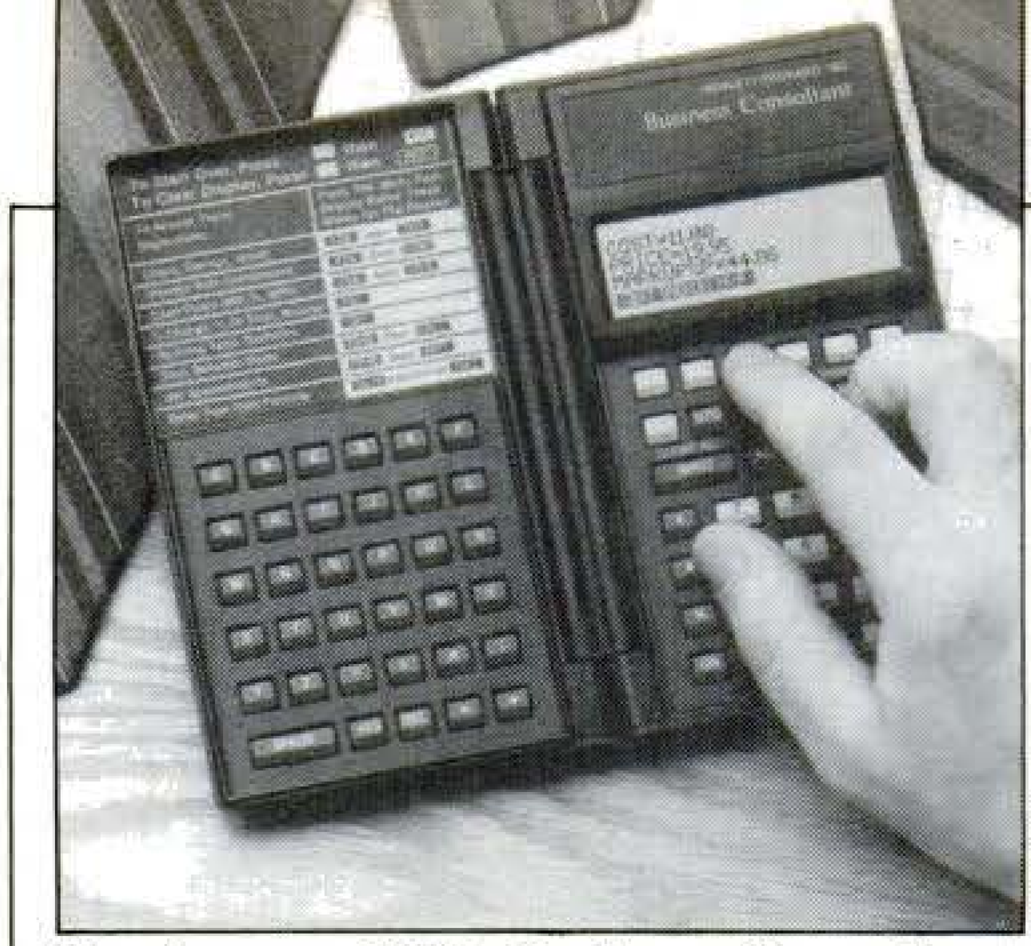


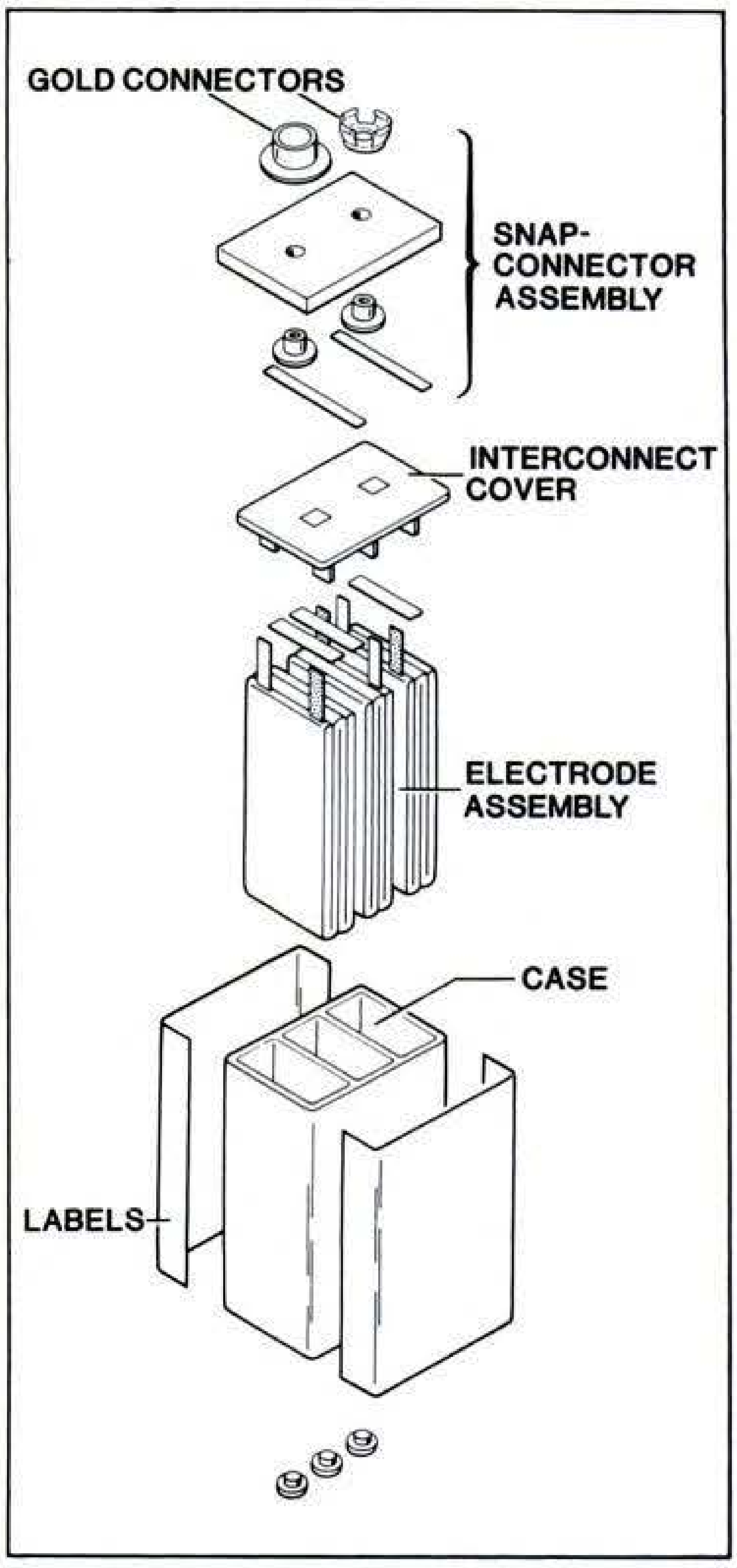
Top keys on HP's Business Consultant calculator are user-programmable.

Kodak batteries

"Go ahead," says actor Robert Conrad in a TV commercial as he eyes the battery on his shoulder. "I dare you to knock it off." Eastman Kodak Co. is about to try—by putting its marketing muscle behind a new line of batteries. Alkaline batteries will be made in all standard sizes under the Supralife brand name; a new nine-volt lithium battery will be called Ultralife.

"It's the first nine-volt lithium battery available to consumers," says James Moxley, president of Kodak's Ultra Technologies group. "It outlasts alkalines by as much as two-and-a-half times."

Unlike other nine-volt batteries, which are made of six 1.5-volt round cells, the Ultralife battery is made of three rectangular three-volt cells that fold into the case to conserve space and weight (see drawing). Gold contacts are used to avoid oxidation, and shelf life, according to Moxley, is about 10 years. Your turn, Robert.



Kodak's folded lithium battery cells fit into a standard 9-V container.

Last-minute updates

- Since the PS article on the new JVC one-hour VHS-C camcorder ["VHS Strikes Back," June], Matsushita, Hitachi, Minolta, and Sharp have joined JVC and Zenith in the compact camcorder camp. Spokesmen for RCA and Panasonic told me that their companies remain uncommitted at present. (Both make full-size VHS models.)
- Sony has become the second company to show a prototype of a digital audio tape (DAT) recorder (see article this issue). The first was Onkyo ["Electronics Newsfront," May]. PS

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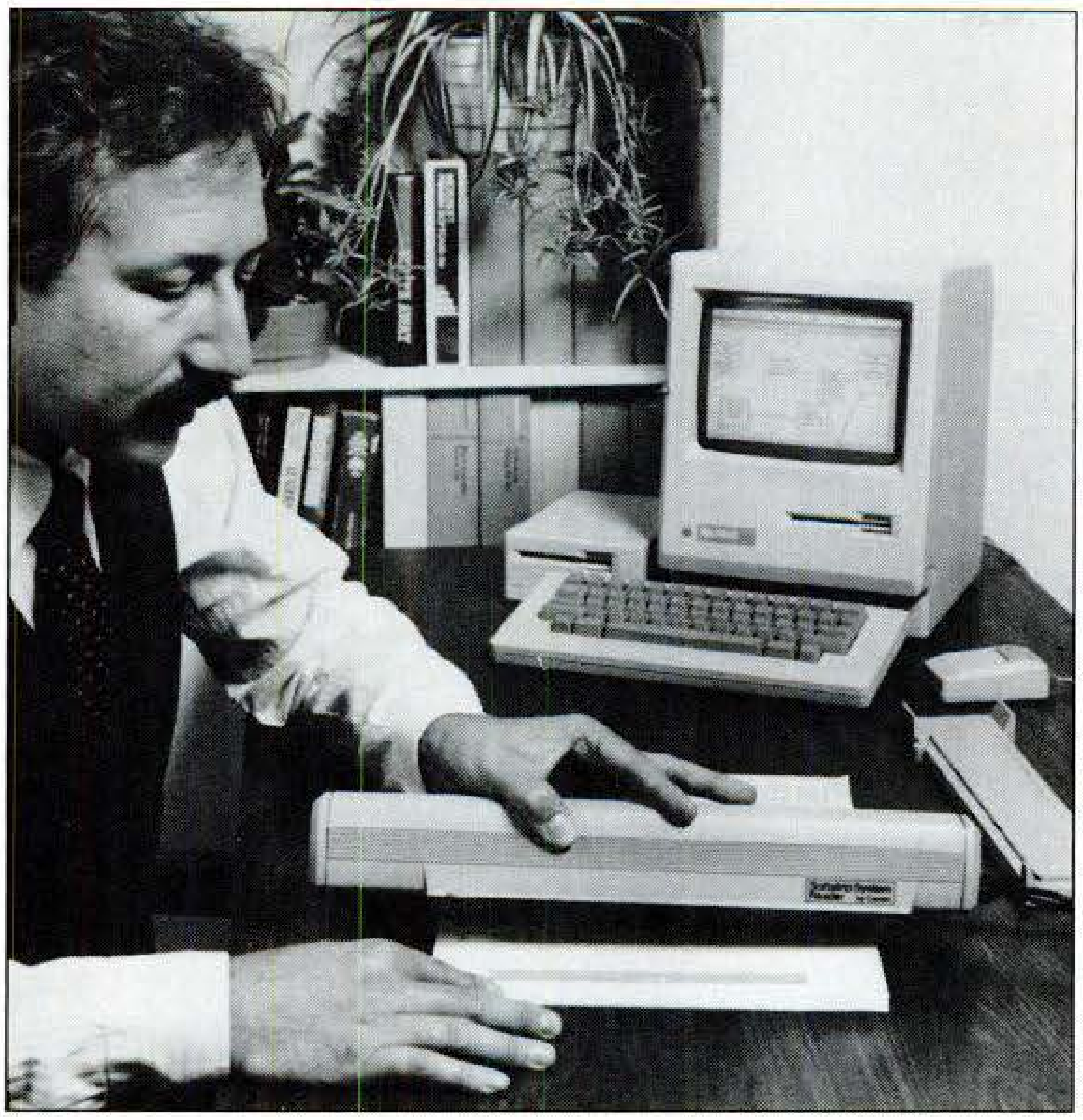
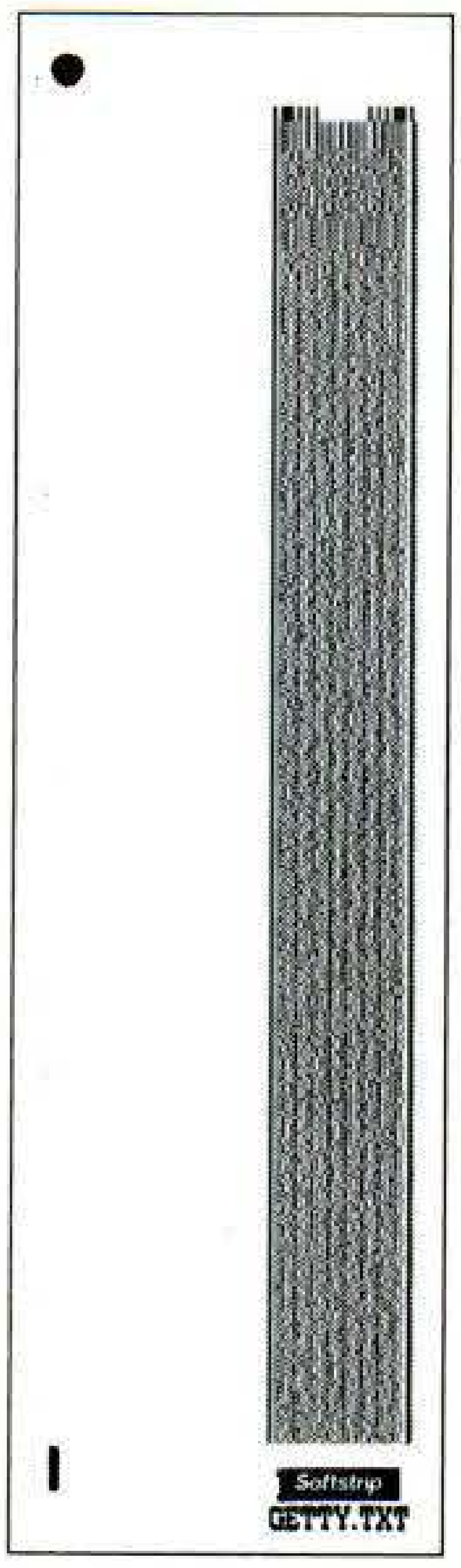




FOUR SCORE AND SEVEN YEARS AGO... The text looks familiar as the full 276-word "Gettysburg Address" streams across the screen of my computer. Its source? The odd-looking black-and-white strip printed above. Called Softstrip, it contains data printed in a format that can be read by a new $200 device attached to an Apple or IBM personal computer.

"Because a Softstrip can be printed in magazines and books, data, text, and programs can be distributed quickly and inexpensively, without regard to disk sizes and formats," says developer Neil Kleinfeld of Cauzin Systems (835 S. Main St., Waterbury, Conn. 06706).

The printed Softstrip—a sort of high-density bar code for computers —contains data encoded in horizontal lines that are 0.012 inch high. A nine-inch strip can contain as many as 5,500 characters, although, says Kleinfeld, "three thousand is more typical." The strip also contains information about the data: file name, length, and special codes for error correction.

The Softstrip reader (photo) attaches to a computer's serial (interface) connection. It contains a motorized scanning head that reads the strip with infrared light to retrieve the data. To use the reader, you place it above a Softstrip (aligning the reader's base with the dot and black line next to the strip) and start a communications program called CAUZCOM (included with the system).

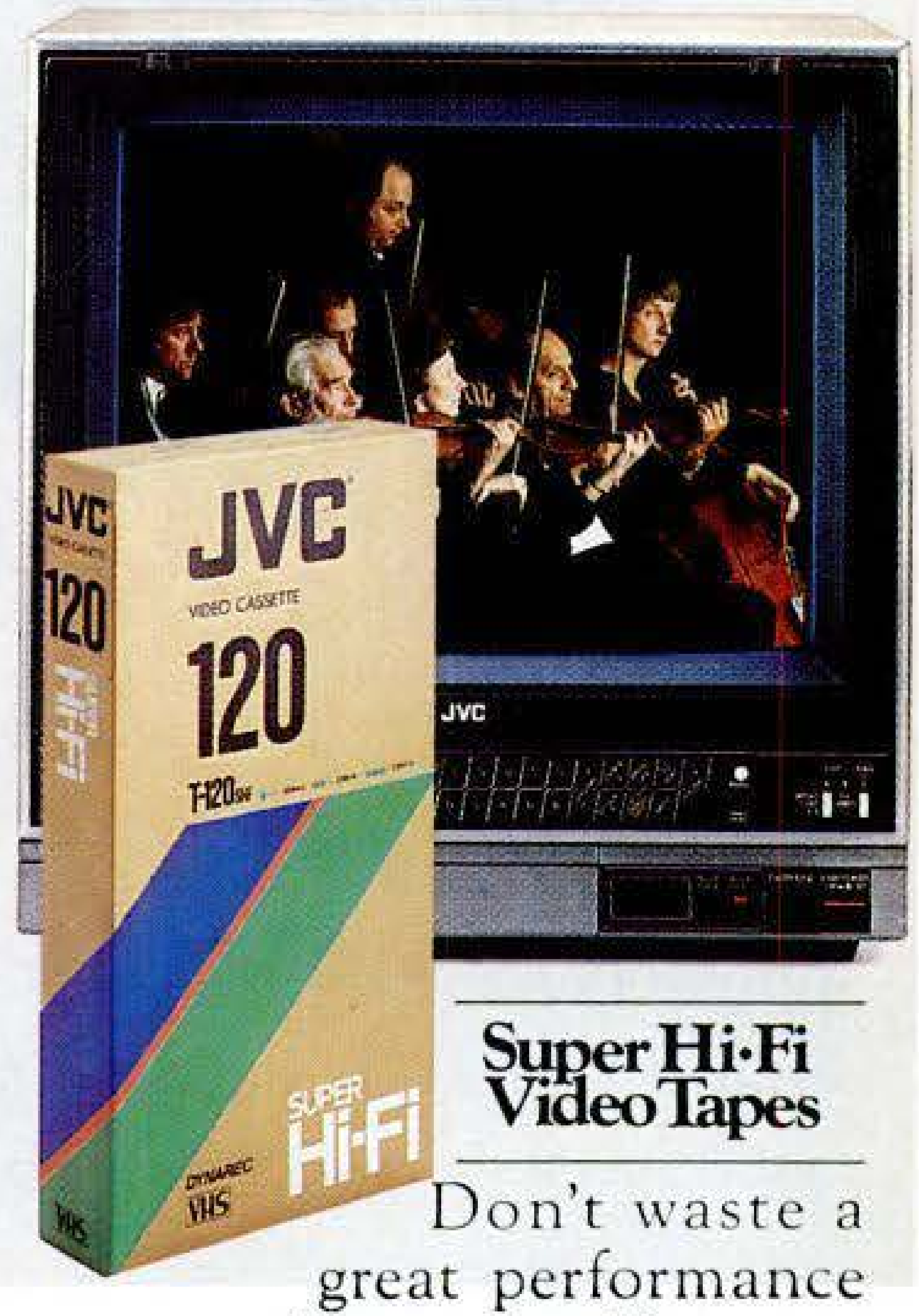
The program displays four menu choices on your computer's screen: READ, to begin reading a Softstrip; HELP, for on-screen instructions; OPTIONS, for special uses such as saving the data on a different disk drive; and QUIT, to stop all operations.

You press the computer keyboard's R key to select the "read" command from the menu. As data are sent, the computer's screen displays the name of the file and a countdown of characters that are read. Speed? It takes less than 20 seconds to send the entire "Gettysburg Address" to a disk file for saving.

I try a number of ways to foil the reader. But because its infrared scanner sees through color, neither coffee nor water stains slow it down; coloring a strip with a felt-tipped pen has no effect. Folding and creasing the paper—even balling it up—cause no permanent errors.

Computer magazines could be the first to make use of Softstrips—as a way to offer programs and data; however, Kleinfeld envisions many more possibilities. "Eventually, bank and credit-card statements may include a Softstrip for automatic reconciliation," Kleinfeld tells me. Then he hands me his business card. A one-inch strip on the card's surface contains the names of the 33 original Cauzin employees.

—*Donald B. Trivette*



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POPULAR SCIENCE CAR TEST #209
Total cars tested to date: 753

High rollers

Acura challenges BMW and Mercedes

Acura Legend is the first $20,000 sedan imported from Japan. Our tests reveal how it compares with two recognized leaders in the high-price luxury-car class.

By TOM WILKINSON
and JACK KEEBLER
Photos by Greg Sharko

They came. They saw. They conquered. That's how it happened a decade ago, when Japanese car makers overwhelmed the United States small-car market. Is the same thing about to happen in the luxury-sedan class?

For the last couple of years, Japanese automobile manufacturers have been nipping at the edges of the luxury market, building cars that are bigger, faster, more luxurious, and more expensive. Now Honda, under its Acura brand name, is making a frontal assault with its $20,000 Legend sedan. This latest —and most expensive—challenger is built by the same people who brought you the Civic and Accord, not to mention some pretty good motorcycles, lawn mowers, and outboard motors.

But can Honda build a car worth $20,000?

To find out, we tested the Legend against two luxury leaders: the BMW 325e and Mercedes-Benz 190E. We found that the Acura compared well with the two German sedans. But by the end of the test, we were having a hard time defining exactly what it is that makes a car buyer willing to spend $20,000 or more for a compact sedan.

Short stops

One thing an expensive car should do is stop well. All three vehicles in this test had the right hardware—four-wheel disc brakes—and the BMW and Mercedes-Benz also had electronic anti-lock systems.

The shortest stops were made by the BMW by a wide margin—with a 141-foot hot stop from 60 mph. The Mercedes posted a respectable 165-foot hot stop. To be honest, we expected no less. Anti-lock allows each wheel to generate as much stopping power as possible. Add four-wheel discs and high-performance radials, and short stops should be the rule.

The Acura's strong braking came as a pleasant surprise, though. With its discs heated by 10 stops from 60 mph, and without the benefit of an anti-lock braking system, it stopped in just 154

Polished performers (clockwise from top): Acura Legend dodges a row of cones during the low-speed test. Mercedes-Benz 190E dips its nose during hard braking, while the BMW 325e waltzes through the PS slalom.

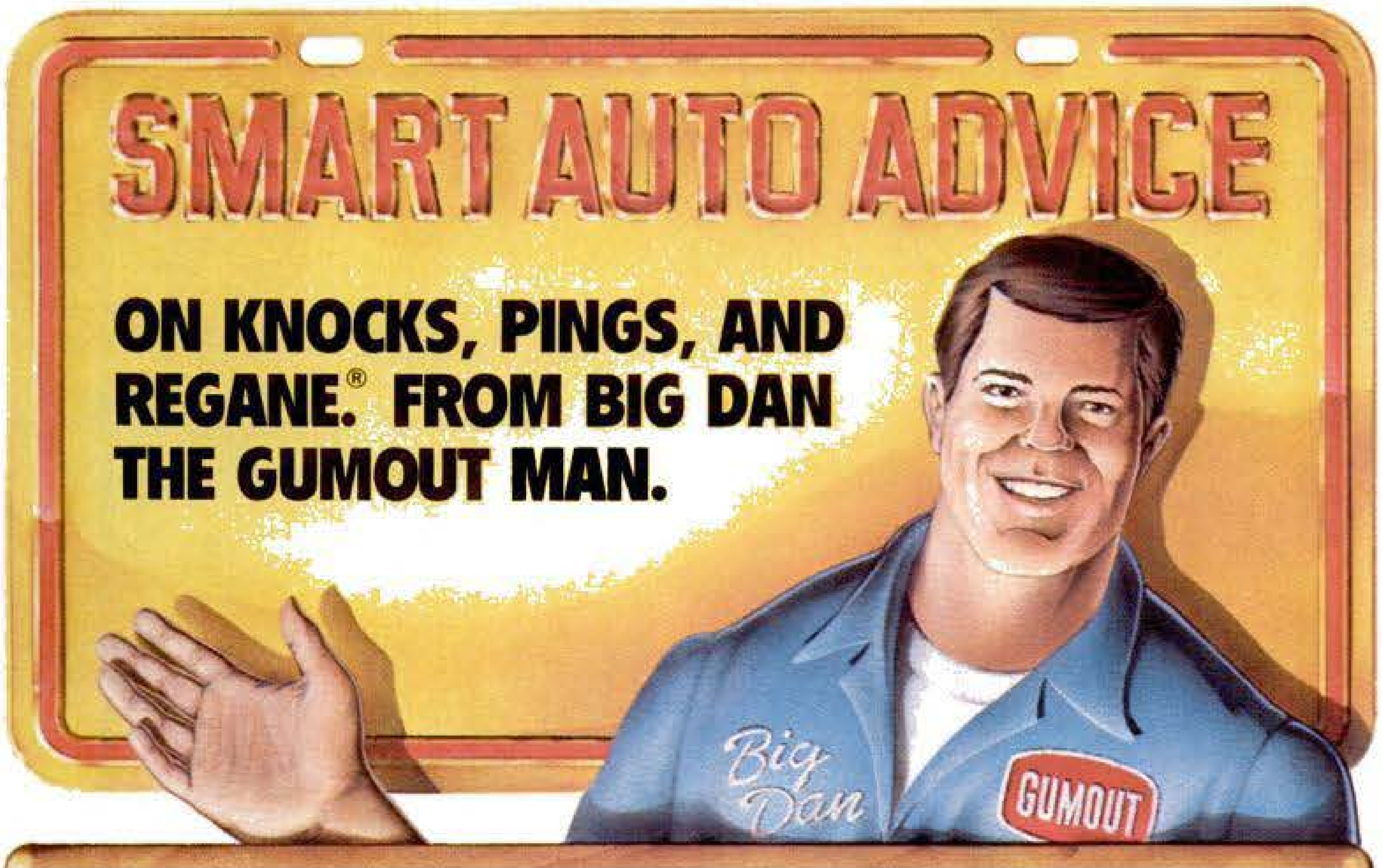
feet. Like those of the BMW and Mercedes, the Acura's stops were dead-center in the braking lane, without a trace of wheel lockup.

Sharp-eyed readers may notice that pedal pressures were very high for the cars with anti-lock. That reflects a change in driving style, not a problem with the brakes. To ensure the shortest stops with anti-lock, the driver simply mashes the pedal and lets the computer modulate the braking at each wheel. In contrast, the Acura, like most cars, needs a sensitive foot on the pedal to get short stopping distances without locking a wheel.

Sophisticated muscle

Along with good brakes, an expensive car should also have a smooth, powerful engine. Traditionally, luxury cars have used large-displacement engines to deliver a smooth surge of power. The cars in this group, how-

Continued



ON KNOCKS, PINGS, AND REGANE.® FROM BIG DAN THE GUMOUT MAN.

In my experience with automobiles, I've learned that as your car gets older, the knocks get louder. That's because of something called ORI – Octane Requirement Increase. It's caused by harmful deposits that form in the combustion chamber. And it plagues every car that runs on unleaded gasoline.

I know these deposits also cause dieseling – that annoying engine sputtering that occurs after the car's been turned off.

And most folks think the only way to cure it is to step up to costly premium unleaded gasoline, see a mechanic for an engine tune-up, or use an ordinary fuel additive octane booster.

But I found a less expensive, more effective choice from Gumout®. And that's Regane®. The greatest advancement in gasoline-additive technology in a long time.

Regane® cleans all the way down into the engine combustion chamber. It decreases the ORI. Helps eliminate knocks, pings, and dieseling. And it really cleans those carburetors.

You know that most fuel additives, like the traditional octane boosters, only last as long as the tank of gasoline they're poured into. But Regane® is *not* an octane booster. It cleans and keeps cleaning through an average of 11 tankfuls – that's about 2,700 miles of knock-free driving.

And Regane® even helps put a stop to the dirty build-up in gasoline and diesel injectors that can cause noise, rough idling, smoke, misfires, and reduced power.

I tell people, you can use premium unleaded gasoline. You can overhaul your engine. You can use an octane booster every time you fill up. But before you do, try Regane®.

It's formulated to be the best. It'll clean your combustion chambers. And it'll put a stop to the knocks, the pings, and the dieseling.

Regane®. Gumout calls it the technological breakthrough for getting rid of the knocks. I call it the 11-tankful knockout!

REGANE®
2,700 Miles of Knock-Free Driving.

A Quality Product of the Pennzoil Company. PENNZOIL

High rollers *Continued*

ever, rely on engines with sophisticated engineering rather than cubic inches.

The Acura uses a 2.5-liter V6 with four-valve heads and fuel injection. Rated at 151 horsepower, it was the most powerful engine in our test, and was so quiet that you could scarcely hear it at idle.

More traditional was the 2.7-liter in-line six in the BMW. Fitted with a single overhead cam and fuel injection, it, too, was quiet and smooth, roaring just a bit during hard driving.

But perhaps the most impressive engine in this test was in the 190E. On paper, a 2.3-liter four with two valves per cylinder sounds like something that belongs in an economy sedan. But in real life, the engine in the 190E is powerful and civilized, with just a hint of vibration at idle. The key appears to be attention to detail, both in the engine itself and in the sound deadening and rubber mounts used to isolate the engine from the car body.

Equipped with four-speed automatics, all three cars performed well in our acceleration runs. The Acura, with the powerful V6, was the quickest to 60—in just 10.5 seconds. Close behind, the Mercedes sprinted to the mile-a-minute mark in 11 seconds. And just 0.7 of a second behind the Mercedes was the 325e. Some buyers will mourn the passing of those slow-revving V8s. But as the Legend, 190E, and 325e prove, you can have both speed and refinement in a small package.

Spring-and-strut waltz

The numbers generated in our high-speed test suggest that the chassis of all three vehicles are essentially the same. The Legend, 325e, and 190E all blasted through the high-speed lane-change grid at 67.1 mph. But that's where the similarity ends.

PS ratings—test report in a nutshell

The ratings are based on test results and measurements. Results should be read with the understanding that they reflect tests only on our sample cars. An excellent rating is 5 points; very good, 4; good, 3; fair, 2; poor, 1; very poor, 0.

	Acura Legend	BMW 325e	Mercedes-Benz 190E
Acceleration	5	5	5
Braking	3	4	3
Handling	5	5	5
Maneuverability	5	5	5
Quietness	3	2	2
Roominess	4	3	3
Vision	5	5	5
Entry/exit ease	2	2	2
EPA economy	3	3	3
Ride comfort*	4	3	3

*Authors' opinion

For starters, the Legend uses front-wheel drive, while the two German sedans are classic rear-drive designs. The Acura also was more softly sprung than the other two. But during our testing, neither the front drive nor the soft springs presented a problem. Hard acceleration during a turn would gently tug the Legend's steering toward the center; otherwise you might never know the car uses front-wheel drive. And while the soft suspension allowed more body roll during corners, it also made the Legend livable on the worst roads. The only change we sug-

Continued

POPULAR SCIENCE TEST RESULTS

TEST RESULTS	Acura Legend	BMW 325e	Mercedes-Benz 190E
Acceleration (sec.)			
0–30 mph	3.7	4.1	3.6
0–40 mph	5.4	5.4	5.4
0–50 mph	7.6	7.7	7.7
0–60 mph	10.5	11.7	11.0
Brake test (cool) 60–0 mph			
Stopping distance (ft.)	159	121	139
Pedal pressure (lbs.)	30	80	140
Brake test (hot) 60–0 mph			
Stopping distance (ft.)	154	141	165
Pedal pressure (lbs.)	45	110	90
Interior noise @ 60 mph (dBA)	66.0	66.5	67.0
Handling test (mph)	67.1	67.1	67.1
Maneuverability test (mph)	30.1	29.1	32.4
EPA FUEL MILEAGE (mpg)			
Highway	24	27	23
City	19	21	20

TEST CONDITIONS Ambient temperature, 65° F; relative humidity, 60 percent; barometric pressure, 29.7 inches Hg

Dimensions and specs

DIMENSIONS (inches)			
Wheelbase	108.6	101.2	104.9
Overall length	189.4	176.8	175.0
Overall height	54.7	54.3	54.4
Overall width	68.3	64.8	66.1
Track, F/R	59.0/57.5	55.4/55.7	56.3/55.7
Ground clearance	5.9	8.0	8.5
Front head room	37.2	35.5	36.9
Front hip room	51.3	40.0	51.0
Front leg room	42.3	44.0	41.9
Rear head room	36.1	36.4	36.0
Rear hip room	55.1	52.3	51.1
Rear leg room (min.)	34.2	33.1	30.9
Rear knee room (min.)	0.4	0.8	0.5
Couple distance	30.8	29.8	28.5
SPECIFICATIONS			
Engine type	V6	In-line 6	In-line 4
Displacement (cu. in./L)	152.1/2.5	164.3/2.7	140/2.3
Compression ratio	9.0:1	9.0:1	8.0:1
Carburetion	E.F.I.	E.F.I.	F.I.
Net hp @ rpm	151 @ 5,800	121 @ 4,250	120 @ 5,000
Net torque (ft.-lbs.) @ rpm	154 @ 4,500	170 @ 3,250	136 @ 3,500
Transmission	4-speed automatic	4-speed automatic	4-speed automatic
Axle ratio	4.20:1	2.93:1	3.23:1
Tire make	Michelin	Pirelli	Continental
Tire type	MXV	P6 Cinturato radial	Super Contact
Tire size	205/60R-15	195/65R-14	185/65R-15
Steering	Power, rack and pinion	Power, rack and pinion	Power, recirculating ball
Overall steering ratio	17.6:1	21.4:1	16.6:1
Turns, lock to lock	3.45	2.50	3.30
Turn diameter (ft.)	36.1	32.2	35.0
Front suspension	Independent, double wishbone type, coil springs	Independent, MacPherson struts, coil springs	Independent, damper struts, triangular lower control arms, coil springs
Rear suspension	Independent, reduced-friction strut, trailing link, coil springs	Independent, semi-trailing arms, coil springs	Independent, multi-link control for anti-lift and anti-squat, alignment control, coil springs
Front stabilizer-bar diameter (in.)	1.04	0.73	0.87
Rear stabilizer-bar diameter (in.)	0.48	0.48	0.51
Brakes	Power, disc-disc	Power, anti-lock disc-disc	Power, anti-lock disc-disc
Brake swept area (sq. in.)	377.7	n.a.	373.0
Fuel tank (gal.)	18.0	14.5	14.5
Trunk space (cu. ft.)	16.6	14.3	11.7
Liftover height (in.)	n.a.	34	n.a.
Curb weight (lbs.)	3,108	2,833	2,745
F/R weight distribution (%)	63/37	53/47	56/44
Base price	$19,893	$23,255	$25,710
Price as tested	$19,893	$24,615[1]	$28,800[2]

Major options (over $100): [1]limited-slip differential $370, automatic transmission $595; [2]anti-theft system $420, electrically adjusted seats $1,265, ABS $1,405

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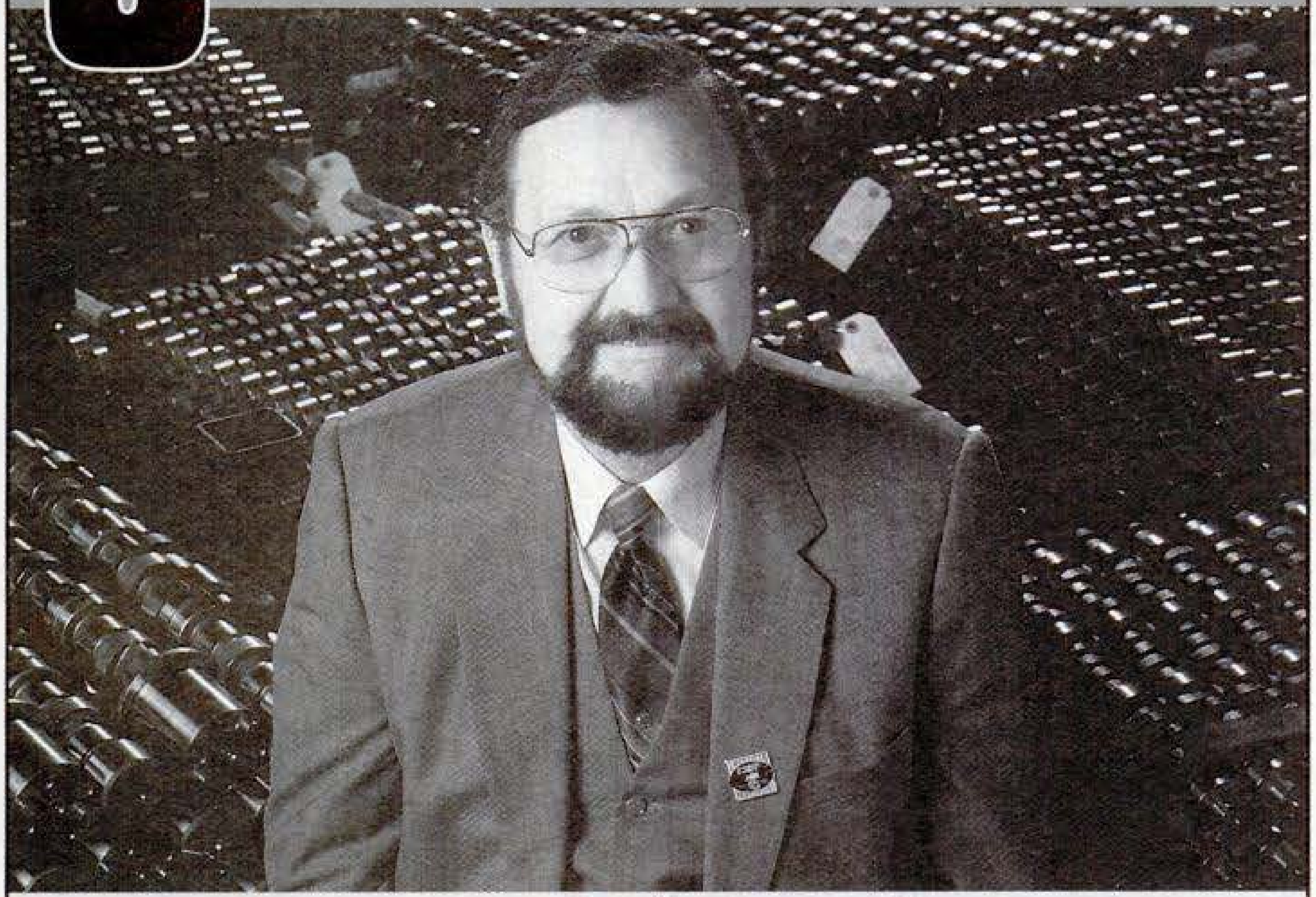

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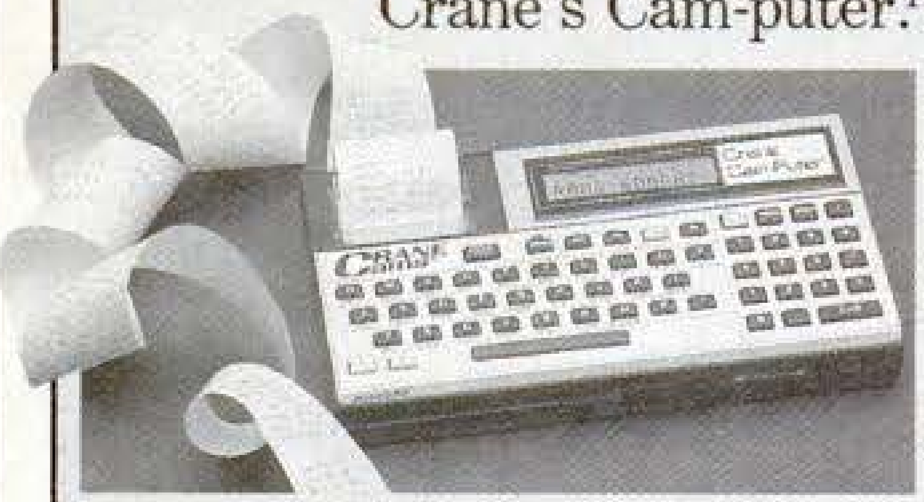

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High rollers *Continued*

gest would be stiffer shock absorbers to reduce float after big bumps.

In contrast, the BMW was easily the stiffest riding of the trio. Fast corners could be taken with just a hint of body roll, and the 325e's grip and balance had us searching for smooth, twisting roads. But we also found ourselves bracing before even the tiniest of potholes. We couldn't help but marvel at how BMW's independent rear suspension provided so little ride comfort.

The Mercedes seemed to have the best compromise between crisp handling and a comfortable ride. Whether on the lunar landscape of New York City's nastiest streets, or on smooth upstate highways, the 190E's four-wheel independent suspension and stiff body structure worked beautifully together. Although the lightest car in the test at some 2,700 pounds, the 190E felt solid and stable at any speed. So much for road-hugging weight. Our only complaint was a minor one: The front and rear suspensions drummed loudly, telegraphing even their smallest movements to the driver.

Inside story

There's little agreement on what the interior of a luxury car should look like. But in our view the interiors of the Acura, BMW, and Mercedes are all on target—tasteful, functional, and relatively simple.

If you like the Honda Accord, you'll feel right at home in the Legend. As with other Japanese cars, there is a good deal of plastic, but it is skillfully fitted, and everything has a quality feeling. A thickly padded steering wheel turns Honda's variable-effort steering. This made parking a one-finger affair, yet provided excellent feel and precision at highway speeds.

Some of our drivers described the front seats as pleasantly firm. Others thought them too hard. And with its long (108-inch) wheelbase, the Legend was the only true four-passenger car in the group; rear-seat passengers were comfortable as long as those in the front weren't much over six feet tall.

If the the interior of the Legend was competent and inoffensive, that of the BMW 325e had character to spare. Each time one of the doors was opened, the delightful aroma of leather wafted into the air like expensive perfume. During our sound tests, one observer noted that, "If it wasn't for the creak of leather, there wouldn't be any noise at all." The gauges and controls were well placed, but the steering wheel was tipped forward at an almost buslike angle.

After a few hundred miles, our test-

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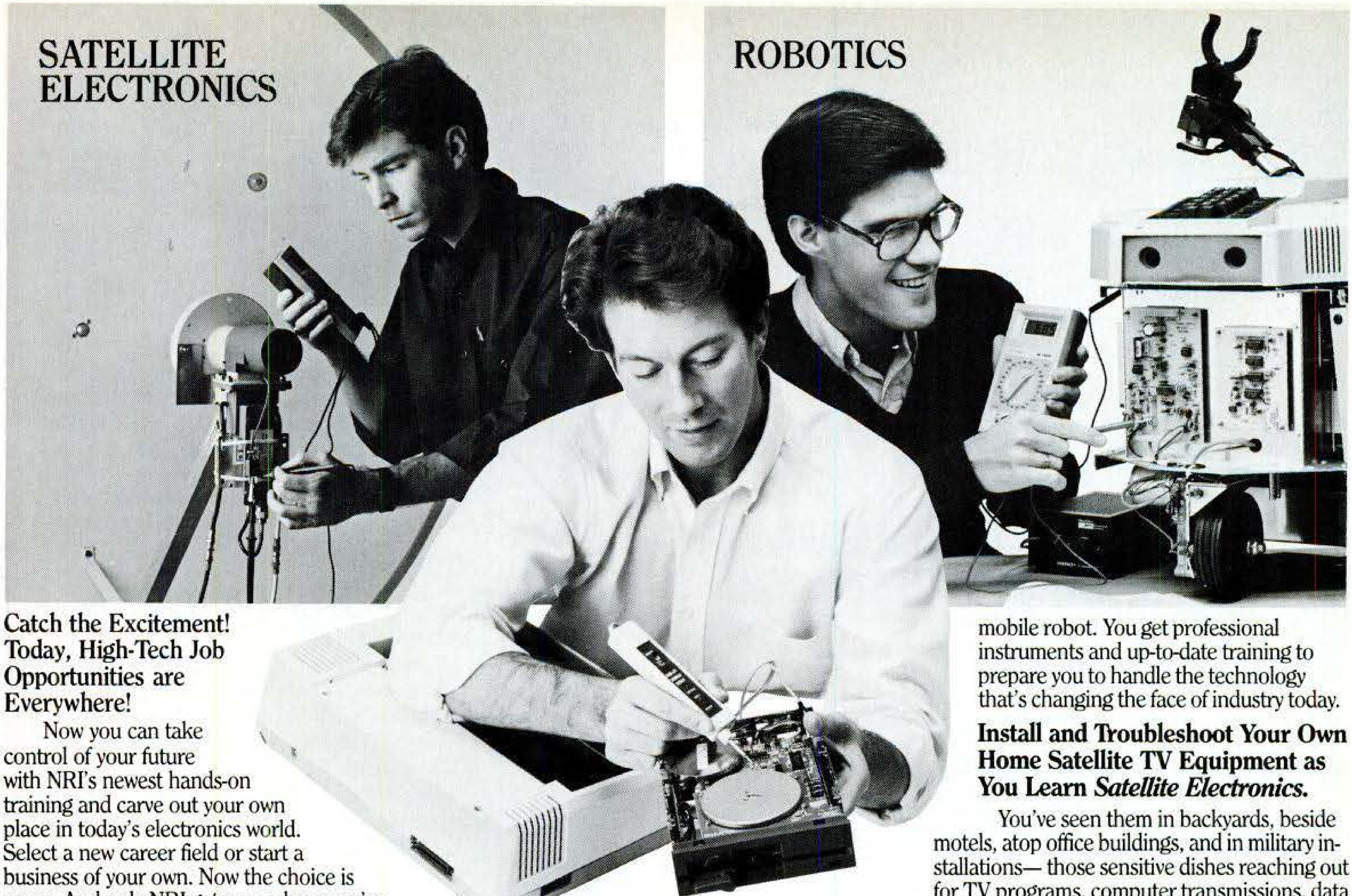

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ers became accustomed to the tilt of the wheel, and we had only minor complaints about the 325e's interior. One driver thought the leather buckets had too little thigh support. And the lack of rear-seat leg room meant that even small kids scuffed and muddied the front seat backs. Finally, there were ugly plugs in the door trim panels intended to hide the holes occupied by the window cranks on European models.

The interior of the 190E drew mixed reviews. Some thought the inside looked like that of a checker cab. Others thought the tan and black interior, with its huge steering wheel, wide vinyl-covered bucket seats, and polished wood trim, was the epitome of low-key elegance.

Everyone did agree that the 190E was a joy on the road. One driver thought the seats needed more lumbar support. Another complained that the padded bolster under the instrument panel pressed constantly against her knees. But the instruments and controls worked perfectly, and it's hard to think of another car that can chew up the miles on a long trip the way the 190E does.

What price luxury?

The more we looked at this trio, the harder it became to define exactly what it is that makes people pay over $20,000 for a small sedan. Certainly performance, comfort, and technical sophistication are part of the equation, and all three cars rated high in these areas.

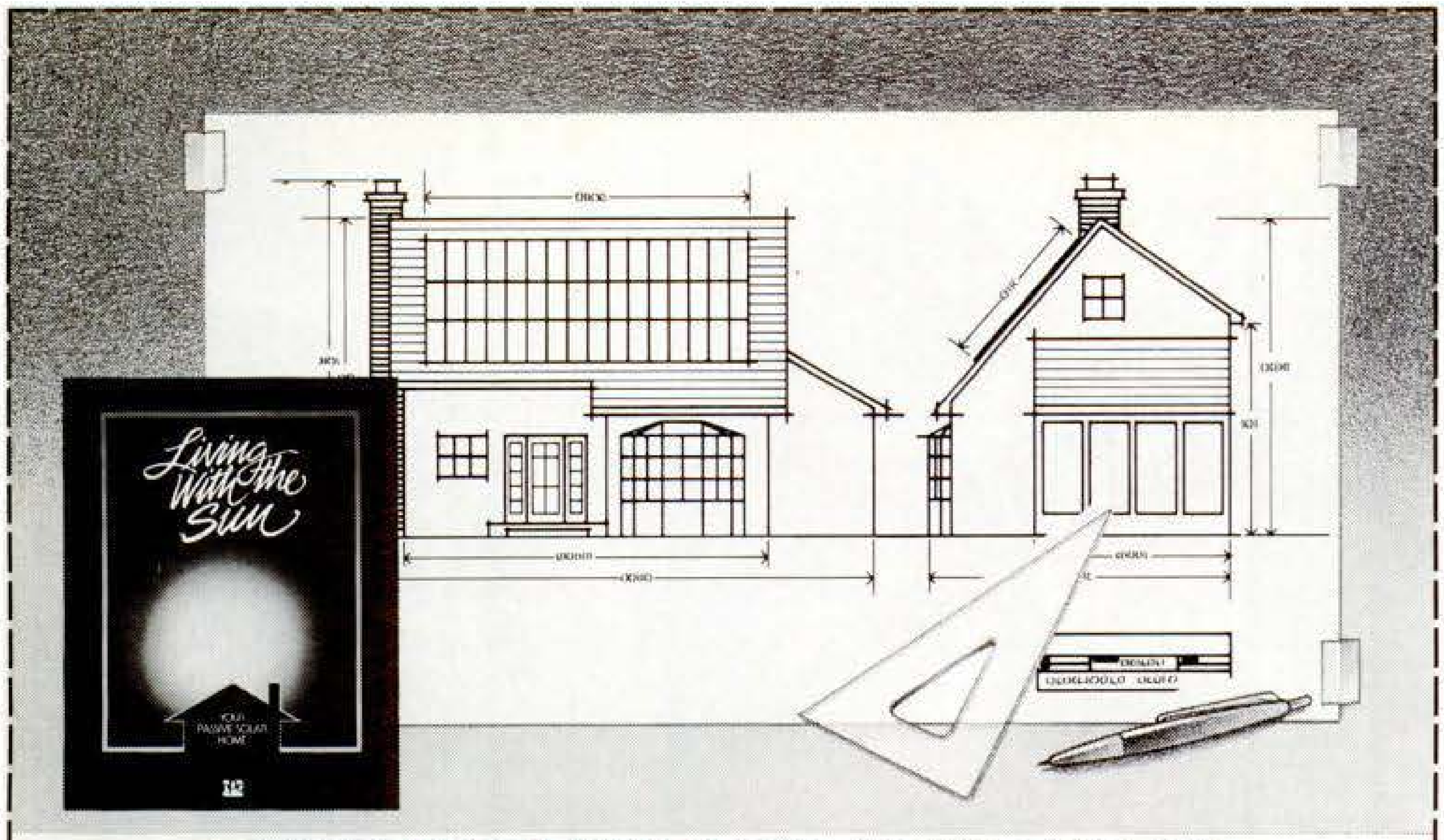
But when we borrowed a Honda Accord LXi for comparison, things became tougher. It's hard to argue that a $28,000 Mercedes 190E is twice as good as the $14,000 Honda. In fact, it's doubtful that the larger body justifies the $6,000 jump in price from the Accord to the Legend.

But of course, buying a luxury car isn't entirely rational. You don't just buy transportation, you also buy the status and exclusivity guaranteed by the three-pointed star or Bavarian breeding. Can Honda, in the guise of Acura, hope to compete with this?

Before you sneer, remember that Europe once dominated the market for such luxury goods as high-performance motorcycles, cameras, and consumer electronics. The Legend may prove to be just the first shot in a long and bloody battle for the hearts—and wallets—of American luxury-car buyers.

Testers' choices

The 325e is expensive, and its ride is harsh. The BMW's rear seat is comfortable only for small children. But



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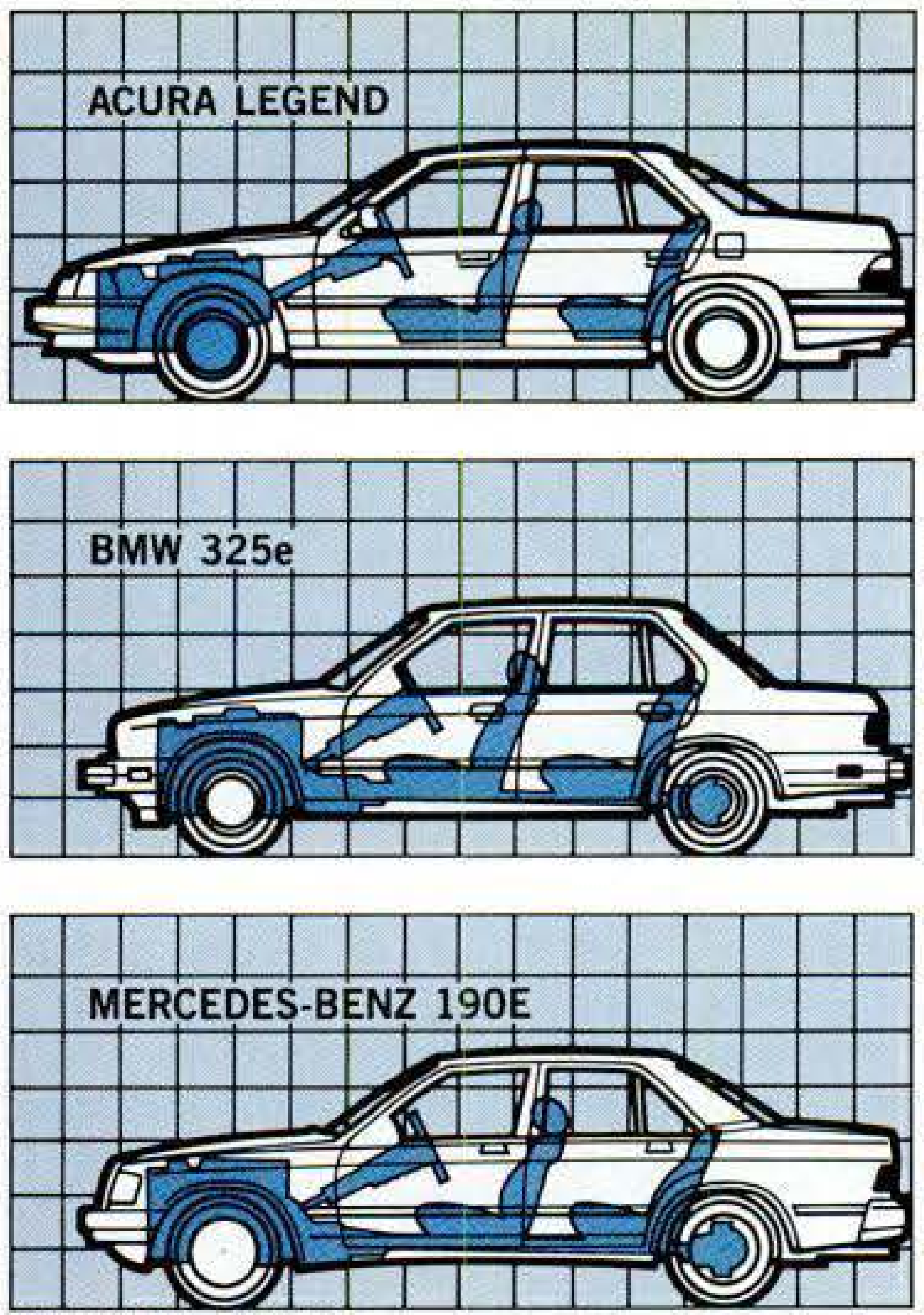

1 GRID BLOCK = 1 SQ. FT.

DRAWINGS BY RUSSELL VON SAUERS

PS serviceability ratings

How easy is it to service these cars? To give you an approximation of how difficult it is for a typical person to perform various service operations, we examine each test vehicle. The numbers mean: 1, very difficult; 2, difficult; 3, average degree of difficulty; 4, easy; 5, very easy.

	Acura Legend	BMW 325e	Mercedes-Benz 190E
CHECKING FLUIDS			
Battery	5	2	5
Master cylinder	5	5	5
Windshield washer	4	5	5
Engine oil	5	5	5
Coolant	5	5	5
CHECKING THE ENGINE			
Spark plugs	4	5	5
Distributor	4	5	5
Oil filter	2	5	2
Oil fill	5	5	5
REPLACING HOSES			
Upper radiator hose	4	5	5
Lower radiator hose	3	3	4
Heater hoses	3	3	2
CHANGING BULBS			
Headlights	3	2	5
Taillights	4	5	5
Front running lights	2	3	4
Front parking lights	4	3	4
Front directionals	5	3	4
Rear directionals	5	5	5
Rear running lights	5	5	5
CHECKING FUSES	4	4	4
CHANGING SPARE TIRE	4	4	4
CHANGING BELTS	3	3	4

there's something about the wail of the BMW's in-line six, the smooth shifts, and the classic too-upright shape that wins my heart and my vote.—J. J. K.

I love the 190E for its superb performance and German feel. But the Legend is fast, comfortable, elegant, and—by luxury-car standards—a real bargain. How can I choose between two of the best sedans in the world? Call it a draw.—T. W. PS

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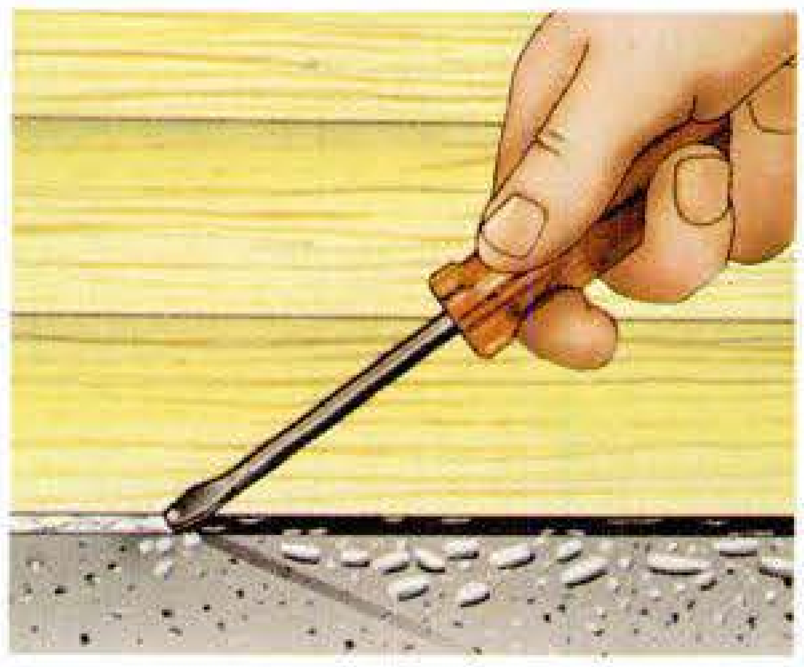
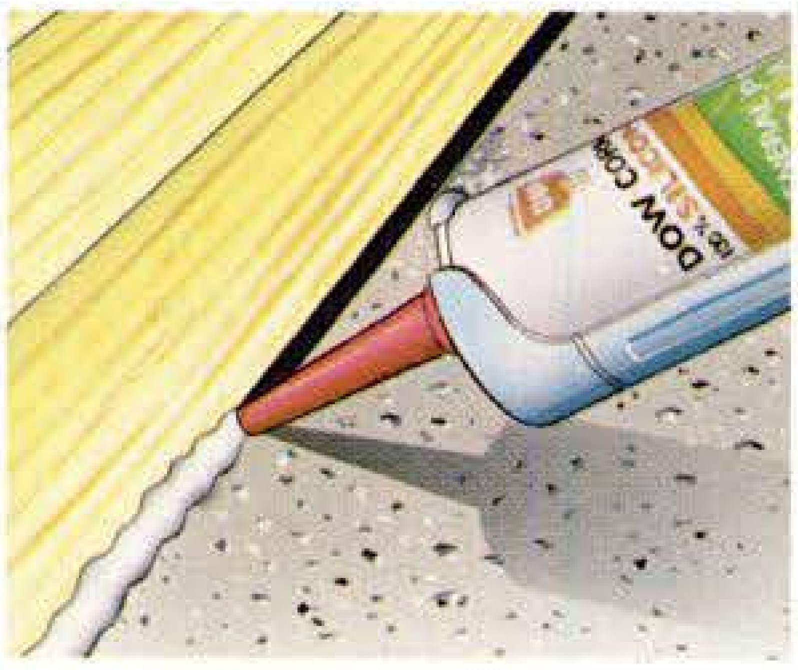


Over time, ordinary caulk cracks and falls apart. When that happens, it's time to remove the old caulk with a screw driver and replace it with a durable seal.



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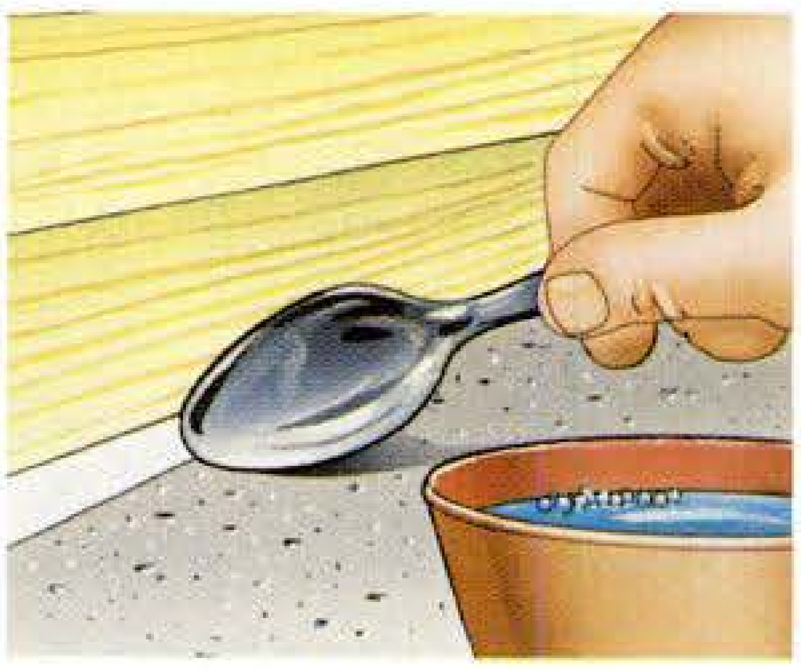

The trick to getting a smooth bead is to tool over the fresh sealant with an old spoon dipped in a soap solution. You'll have a professional-looking long-lasting seal to protect your house!

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What's New

products/technology

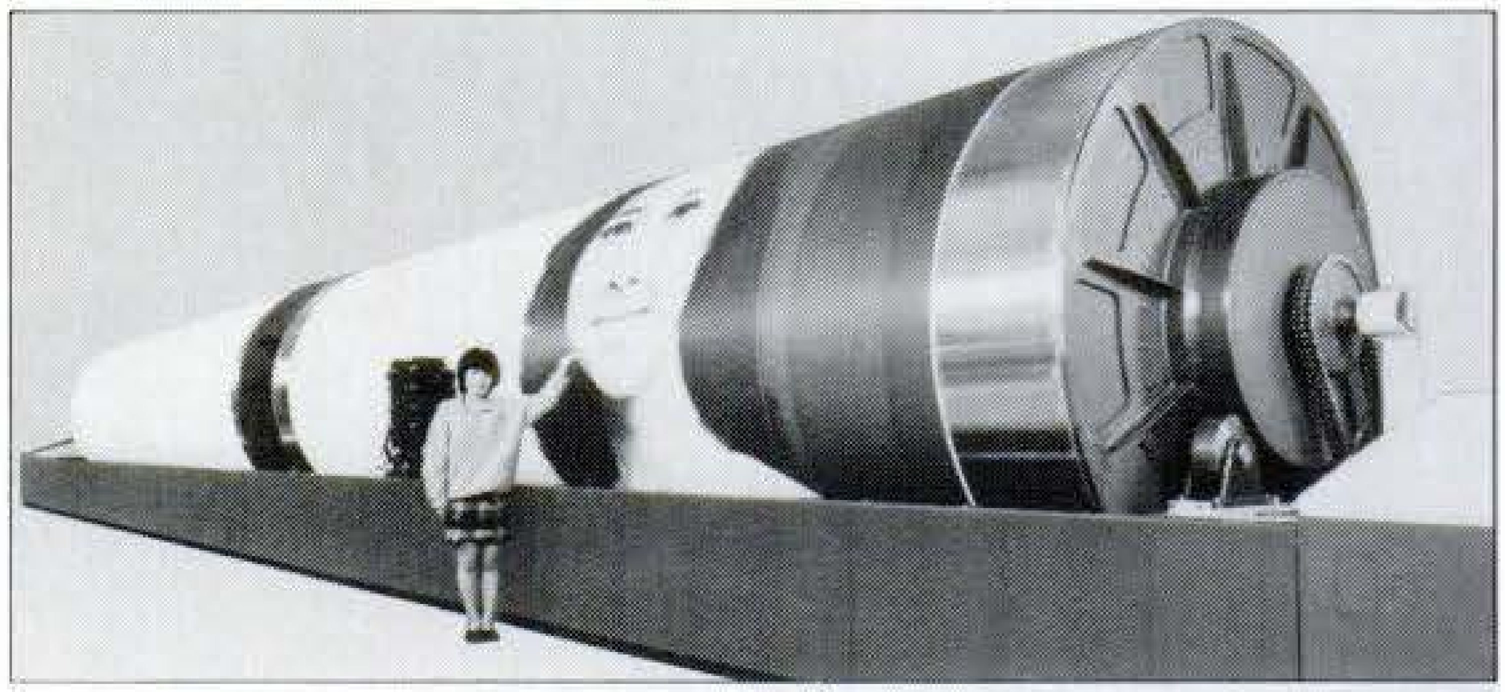
BY DAWN STOVER

Deluxe golf cart

The Sun Classic's top speed is 12 mph, but that's fast enough so that residents of private communities can make quick, short trips. Yamaha included automotive features and an Autolube system that mixes oil and gas for the two-stroke, air-cooled engine.

Solar RV fan

Eliminate mildew odors and make your RV's battery last longer with Trailercool ($280), a solar-powered ventilating fan and battery charger. The fan turns faster as sunshine intensifies. It fits 14-by-14-in. hatches. Solar Electric Engineering, 405 E. D St., Petaluma, Calif. 94952.



Japanese QSTOL

Called Aska (flying bird), this experimental quiet-short-takeoff-and-landing plane is Japan's version of a smaller and older NASA craft. Aska gets extra lift from exhaust outlets blowing over its wings. Sound waves from the engines are deflected upward.

Giant copier

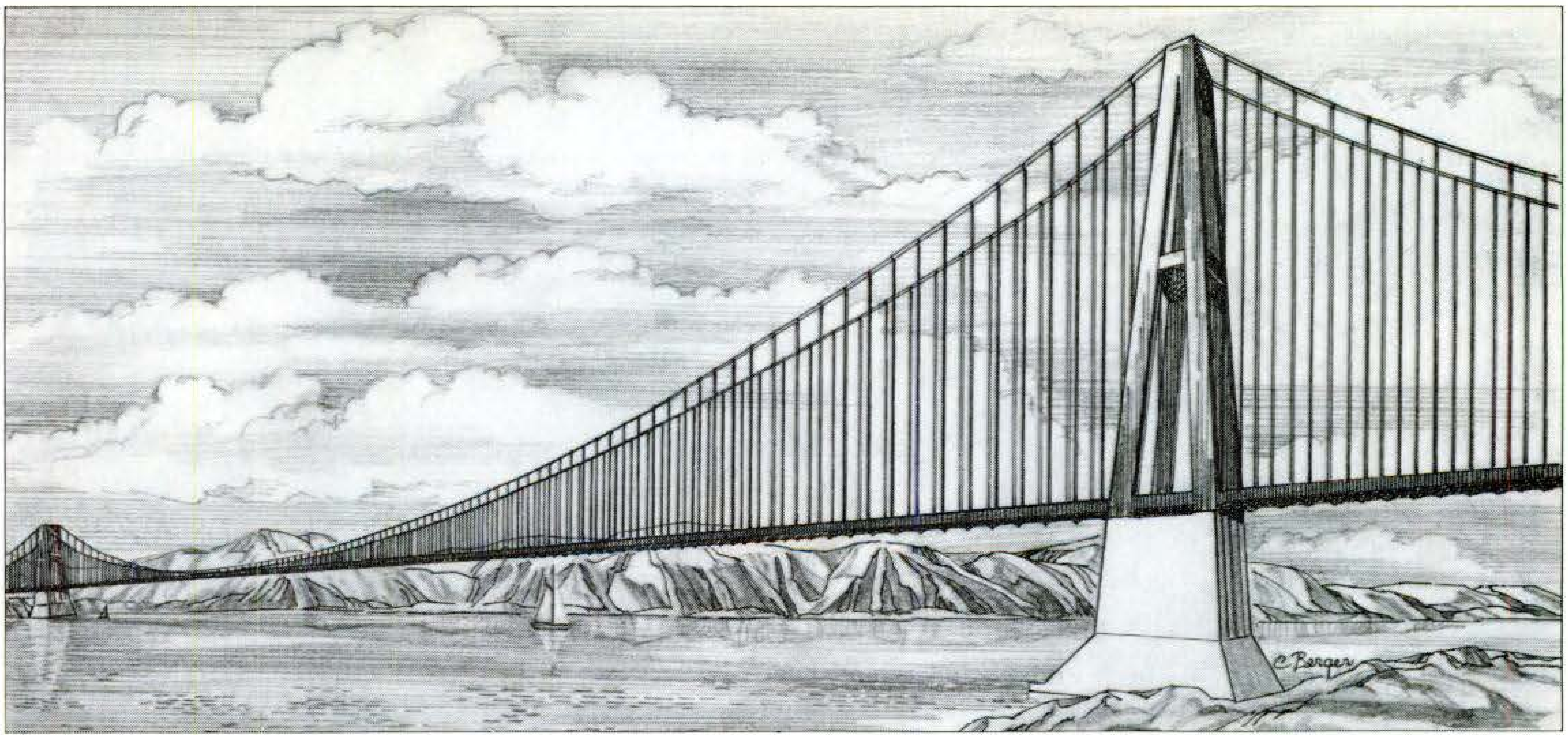
Matsushita's Full-Color Jumbo Facsimile System can take a color snapshot and produce a 23-by-52½-ft. copy of it, large enough for a billboard ad. The machine can create composite pictures and alter colors, or enlarge digitized images received over phone lines.

Star map

Pack this portable planetarium into your knapsack, and you can carry 88 star constellations with you. Night-Star ($45) is made of soft, rubbery plastic that displays any night sky view inside the 8-in.-wide bowl. Night-Star Co., 1334 Brommer St., Santa Cruz, Calif. 95062.

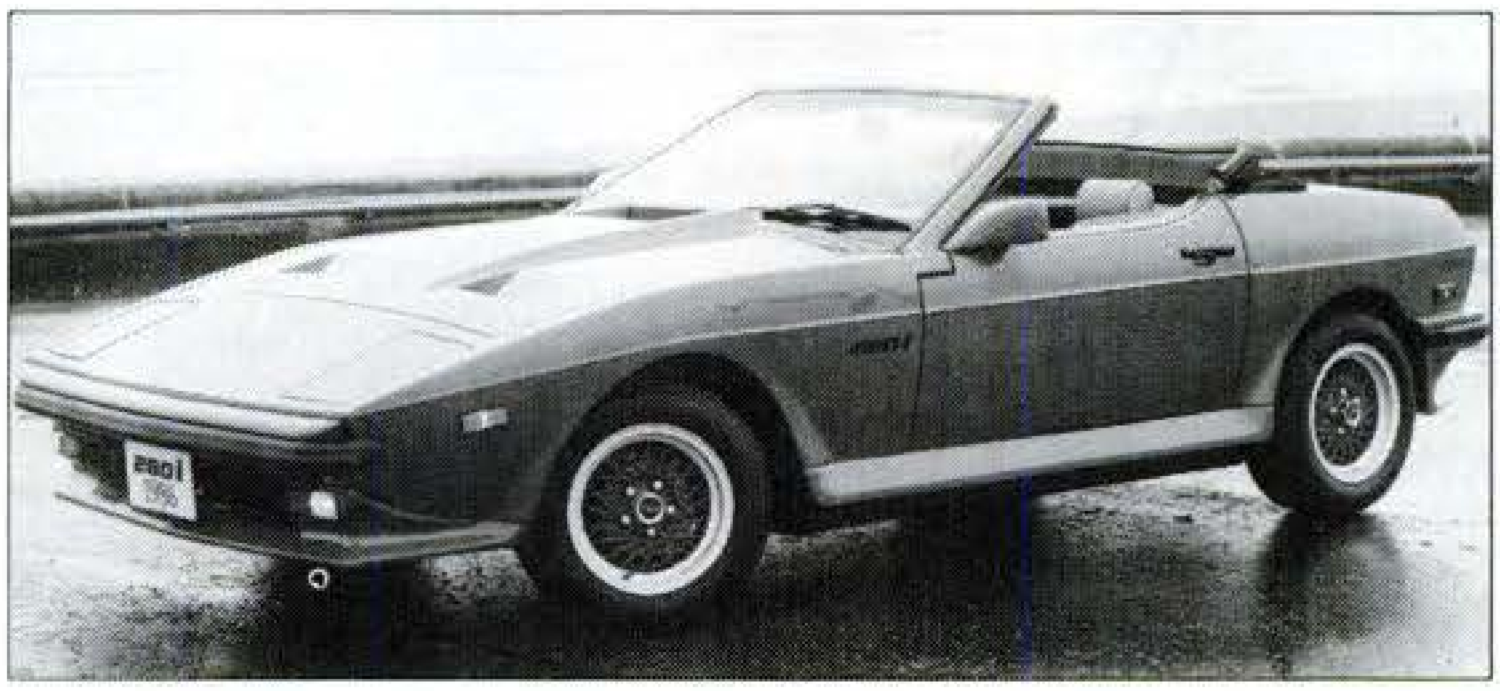
Giant radials

Weighing 7,000 lbs. each, these 11-ft.-dia. radial tires are loaded into special containers at Goodyear's Topeka, Kan., plant. Made with a steel-cord carcass and steel belts for a load capacity of over 111,000 lbs., they're for earth-movers in an Australian coal mine.



Two-mile bridge

This suspension bridge is the favored proposal to link Sicily to the Italian peninsula. Its main span, more than twice the length of any other, would stretch across the Messina Strait. Sunken-tube and floating tunnels are also options, but their costs and risks are higher.

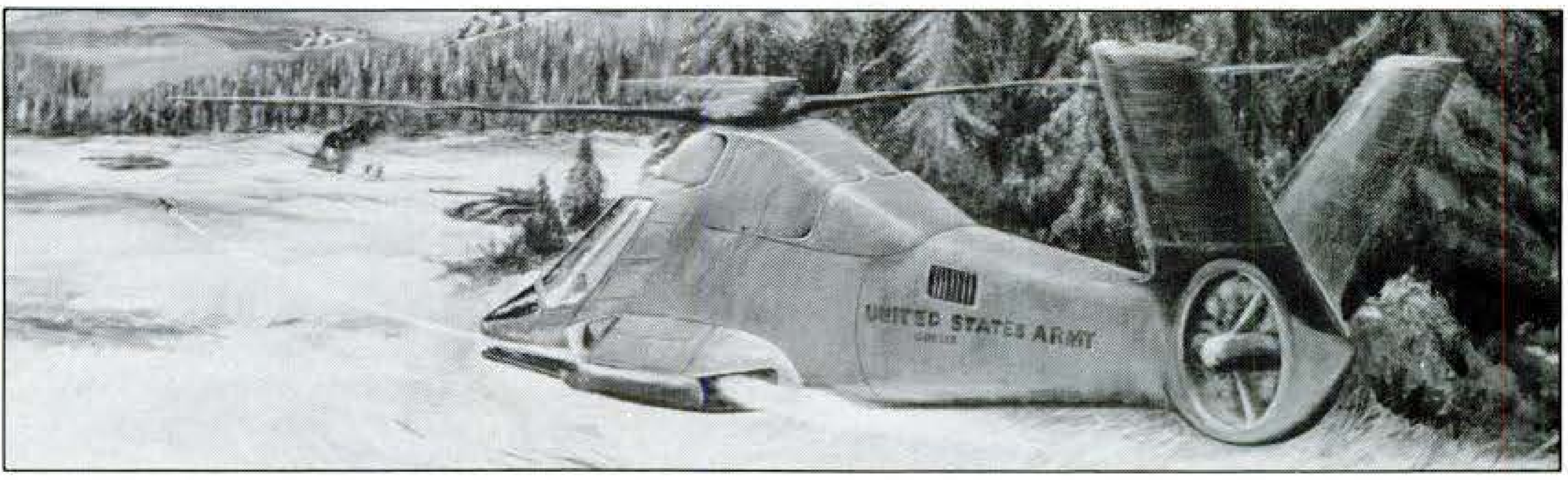


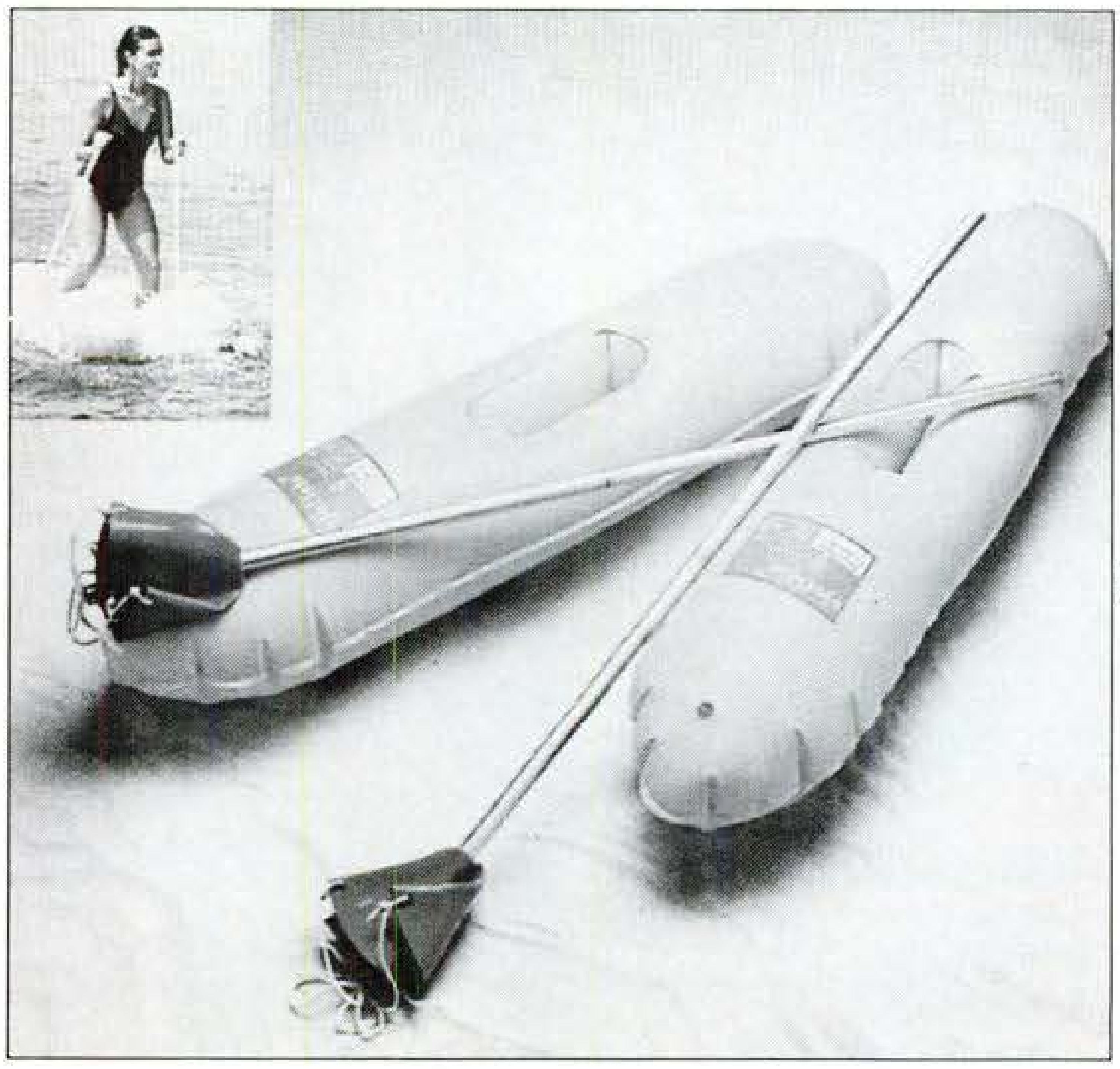
British convertible

Gone are the sharp angles of TVR Engineering's 280i, a convertible that hits 60 mph in 7.5 sec. The revised Series II model now has a more rounded front bumper and air dam. TVR Engineering (Bristol Ave., Blackpool, England FY2 0JF) added insulation to reduce noise.

Light chopper

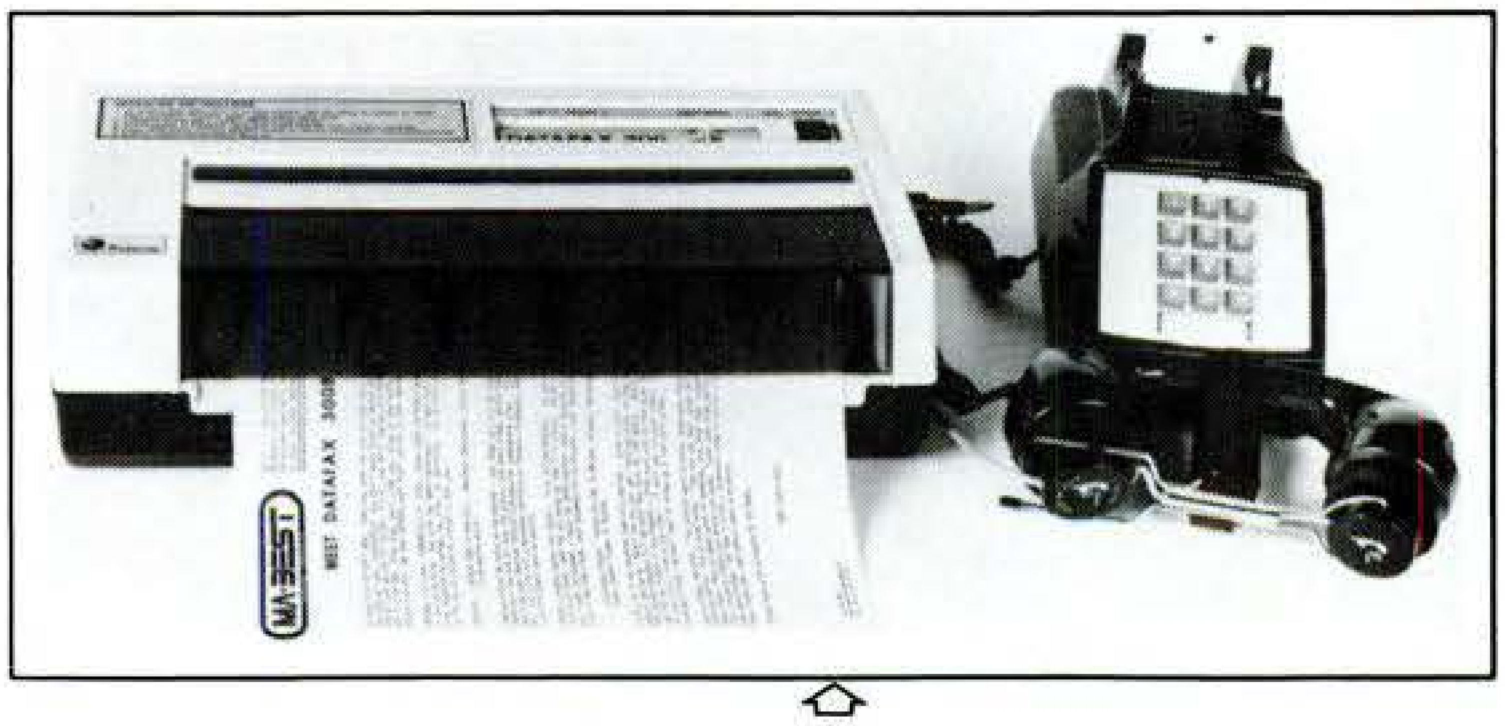
A Boeing Sikorsky team is developing this LHX Army combat helicopter for the late 1990s. The chopper has an enclosed tail rotor and a single-side stick control that responds to hand pressure alone, leaving the solo pilot's feet free to operate weapons or instruments.





Walk on water

Or clean your boat while it is anchored offshore. Inflatable plastic water shoes will support up to 190 lbs. Two aluminum balancing poles, a hand pump, and a repair kit come with the 56-in.-long shoes ($99.50). Hammacher Schlemmer, 147 E. 57th St., New York, N.Y. 10022.



Take-along fax

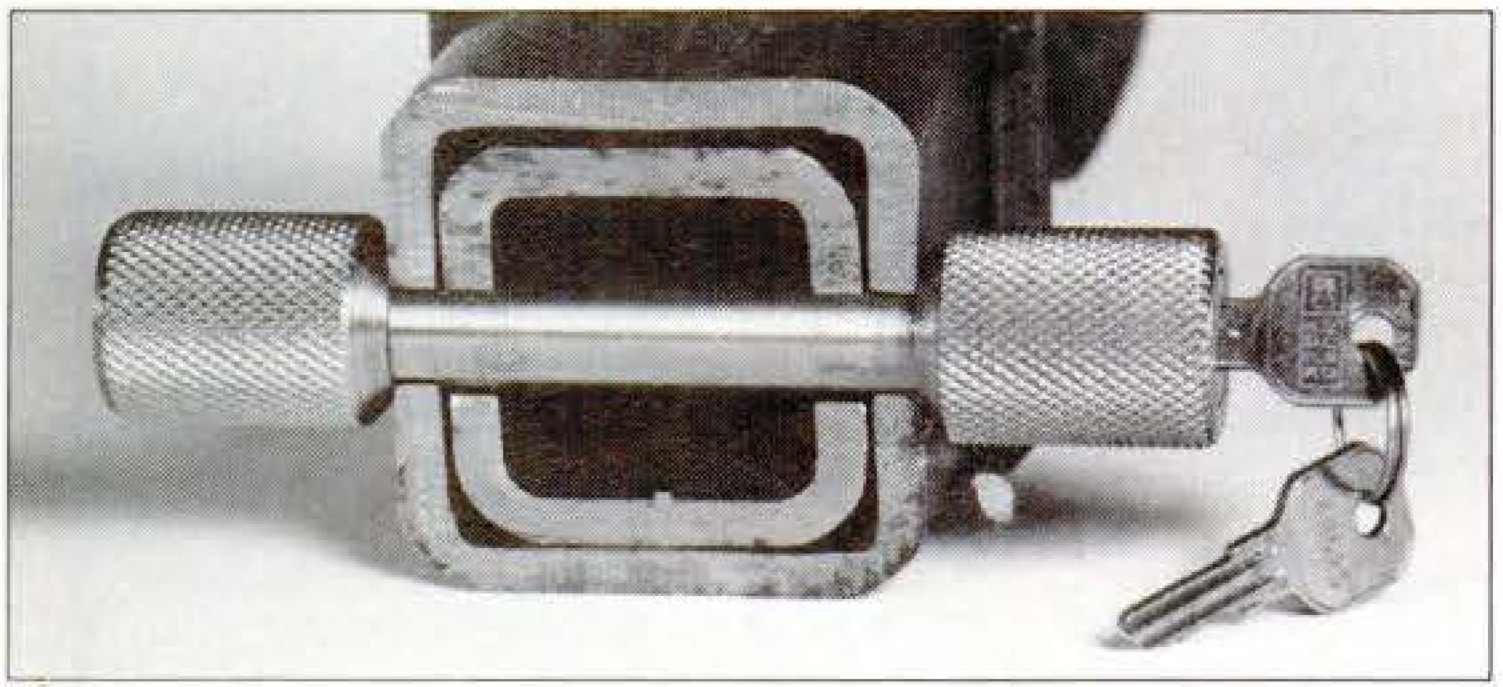
Transmit or receive copies of important documents in your hotel room or car—even at a pay telephone. Datafax is a 14-lb. battery-operated facsimile machine that fits on any phone handset. Ma Best, Box 4522, N. Hollywood, Calif. 91607. It costs $1,195.

What's New
for Your Car

BY JACK KEEBLER

Flagship tire

Michelin's latest VR-rated (over 130 mph) tire, the Sport XGT Plus, is for ultra-high-performance cars. The first size available is a wide 315/40VR16 to fit 1984 and later Corvettes. The company claims the tire can provide 1 *g* of lateral acceleration. Price: $240–$260.



Hitch lock

Push the zinc-plated steel pin through the hitch. Then screw the knurled cap onto the end of the pin. And, finally, remove the key from the cap. Your hitch is now securely locked to the tow vehicle. C. T. Johnson Enterprises, P.O. Drawer 100, Escanaba, Mich. 49829; $14.

Future shock

Monroe claims its new Monro-Matic Plus nitrogen gas shock absorber provides better roll stability in turns, reduces ride harshness, and lowers interior noise for greater comfort. Special valving and gas charging reduce shock fade and provide consistent response.

Stalk alarm

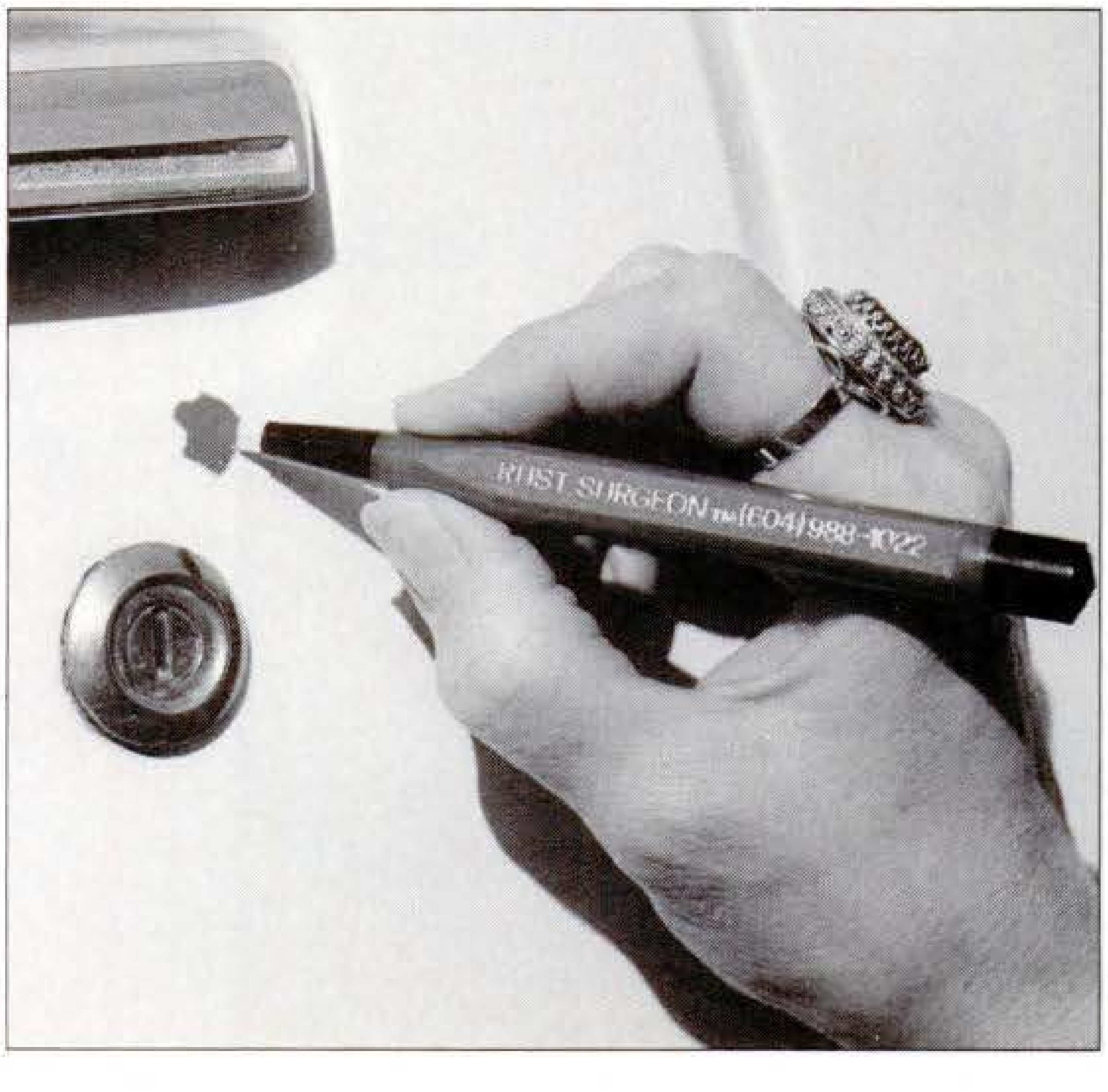
Intercept 1000's key pad lights up at night to let you program exit and entry times, adjust siren cutoff time, recall time of tampering, disable the starter, and perform other functions. Pulsar Mfg., 755 California Dr., Burlingame, Calif. 94010; $995 not installed.

High-mount light

Constructed of polycarbonate plastic, the 3rd Brake Light ($11–$14) is packaged with mounting hardware and instructions for installation. Included is an anti-glare shroud to prevent reflection in the rear window. Wink Corp., 5631 208th St. S.W., Lynnwood, Wash. 98036.

Rust remover

Rust Surgeon is a small pencil-like abrasive tool for removing rust from small scratches. The fiberglass point also feathers the primer and top coat for paint applications, says North Star Sales Ltd. (1671 Haverhill Pl., N. Vancouver, B.C., Canada V7J 1T5). Price: $4.



Compare the new two-wheel drive Jeep® Comanche to Ford Ranger and Chevy S-10, and you'll find Comanche has the lowest price tag. And in 4x4's, Comanche is the lowest-priced long-bed pickup you can buy.*

Up front, a gutsy 117 horsepower 2.5 litre electronic fuel-injected engine is standard. It's more powerful than the base engine of any other pickup in its class.

Comanche's 119.9 inch wheelbase is longer than any other long-bed pickup in its class.

Comanche is the only 4x4 pickup built with a choice of two "shift-on-the-fly" four-wheel drive systems.

You'll find big 15-inch wheels and all-weather radials standard on Comanche, optional on two-wheel drive Ford Ranger and Chevy S-10.

Four Wheeler of the Year.

Safety belts save lives.

---

*Based on manufacturers' suggested retail prices for base long-bed vehicles. Excluding taxes, license, destination charges and optional equipment. Prices may change without notice.

Easy to be a truck. Hard to be a Jeep.

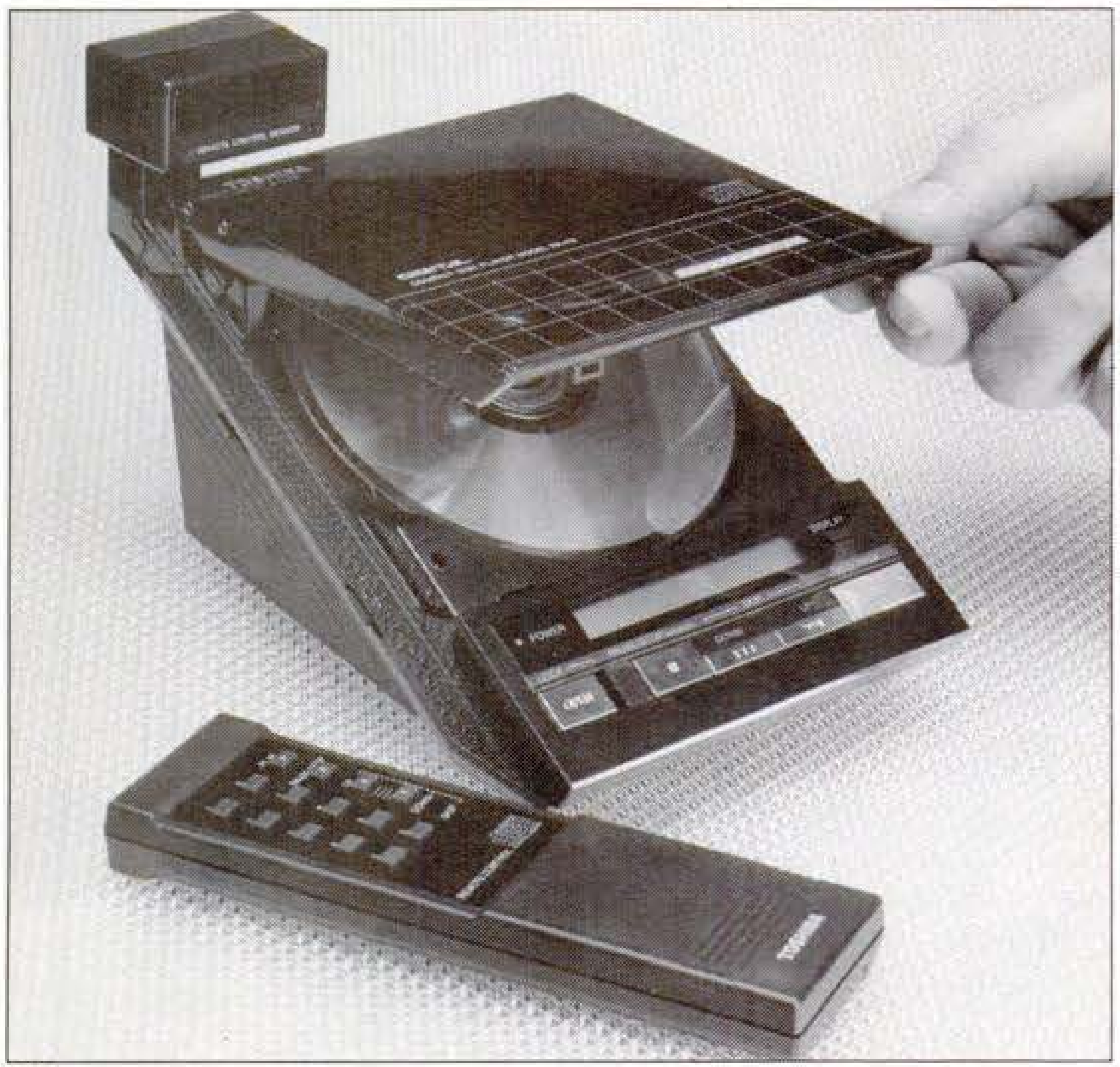
New Jeep Comanche
Available in 2WD and 4WD

What's New *in Electronics*

BY WILLIAM J. HAWKINS

HQ camcorder

Aim...shoot. The RCA CMR300 Pro Wonder camcorder takes HQ—high-quality—pictures in light levels as low as 7 lux. The time and date from its built-in clock/calendar can be recorded with the image on a full-size VHS video cassette. With 2-hr. battery, it's $1,499.



Two-way CD player

Snap on the remote-control eye (rear of large unit) and slide in its AC power supply (bottom of unit), and the Toshiba XR-P9 CD player ($300) becomes part of your stereo system. Don't do these things, and it remains a portable that plays for 9 hrs. using its battery pack.

VCR extender

Attach the master box (bottom) to your VCR and the slave (top) to any TV in your home. Result: remote VCR viewing and control at the TV. A two-conductor wire can connect five $45 slaves to the $90 master. Rabbit Systems, 233 Wilshire Blvd., Santa Monica, Calif. 90401.

Speedy keyboard

Simultaneously press two keys on the RapidWriter computer keyboard. It converts the abbreviation into an assigned word, phrase, or paragraph. Typists can double their speed, claims Quixote Corp. (1 E. Wacker Dr., Chicago, Ill. 60601). It's $595.

Brainy typewriter

Smith Corona's $560 XD-8000 electronic typewriter checks for mispellings, double double words words, and Capital Letters at the beginning of sentences. If anything's wrong, it shows you the error on its LCD display and allows you to make corrections anywhere on the page.

Sporty camcorder

Now take poolside shots from a different perspective. The Sony Handycam Sports camcorder is water and shock resistant, and intended for rugged outdoor use. (It's not designed to be immersed in water, however.) The $1,350 unit records for up to 2 hrs. on one 8-mm cassette.

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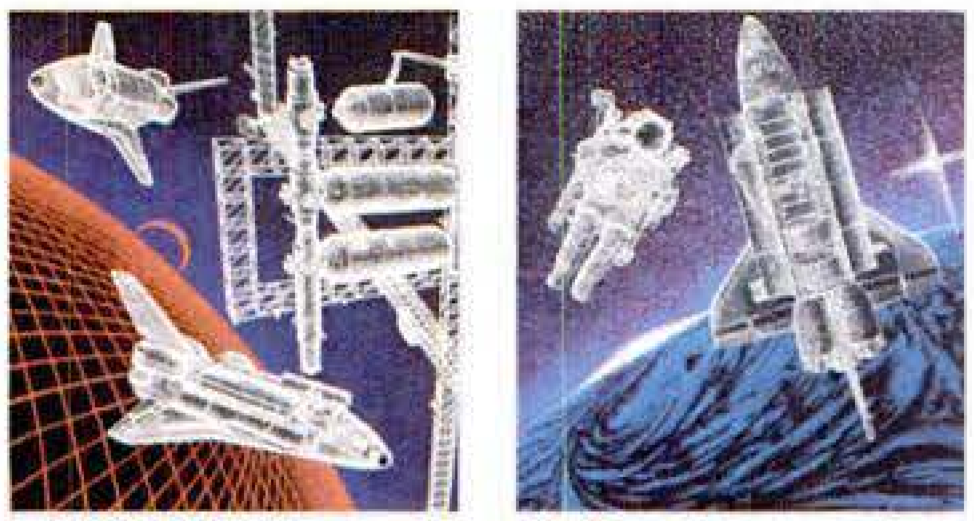
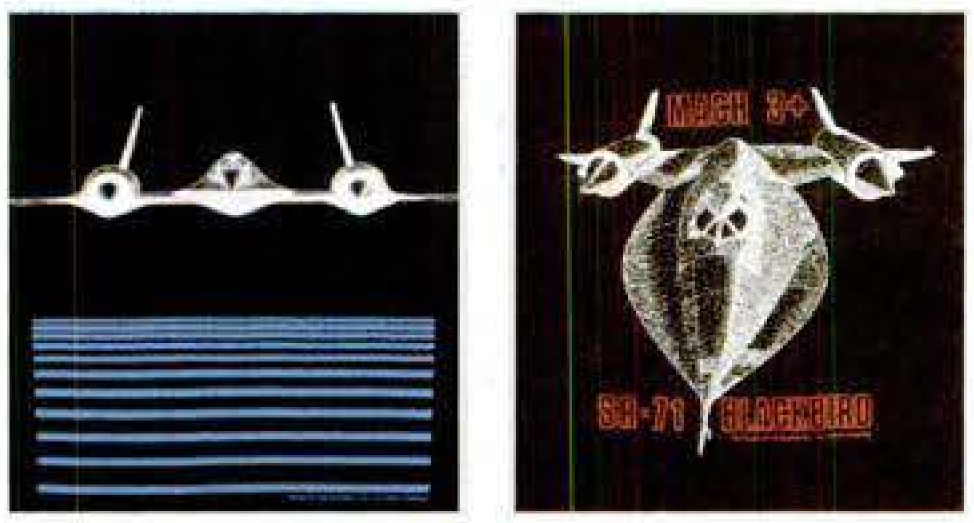
UH-60 BLACKHAWK



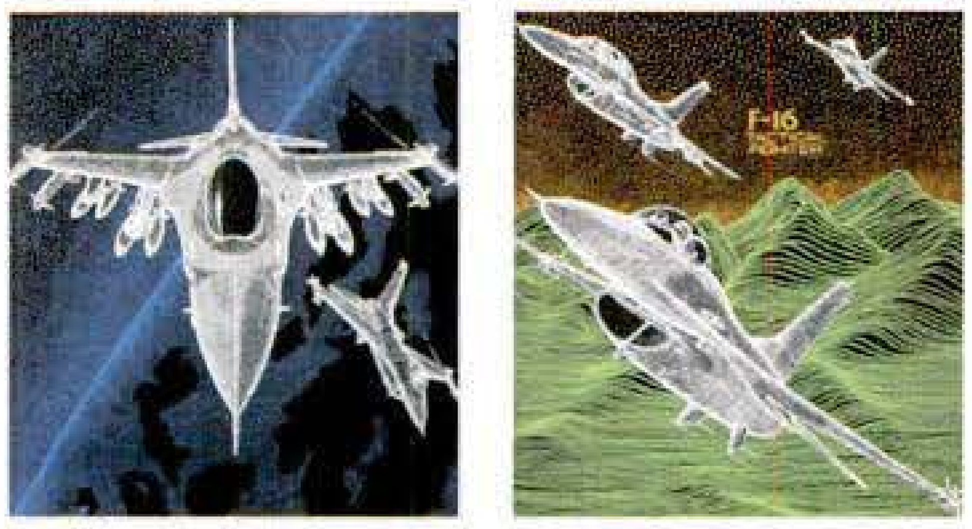
FRONT SPACE SHUTTLE BACK

FRONT BACK FRONT BACK

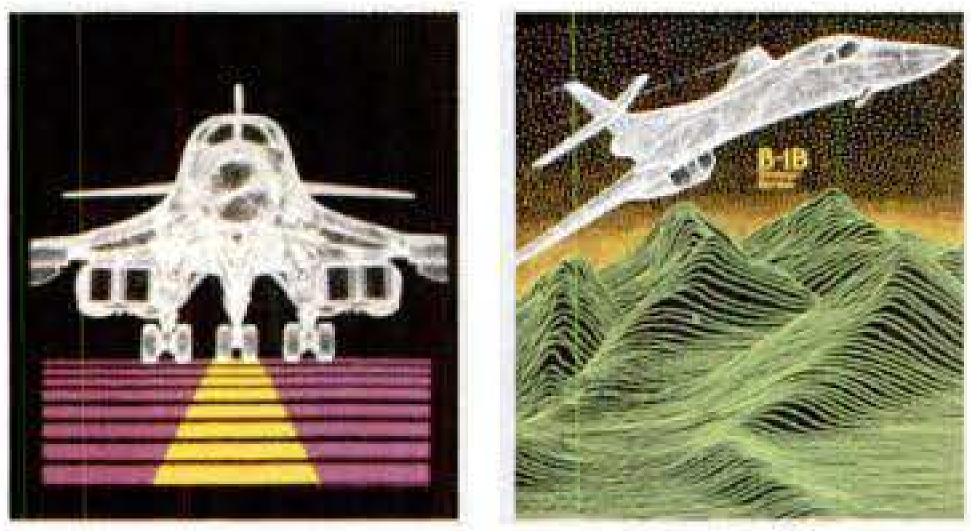


SR-71 BLACKBIRD

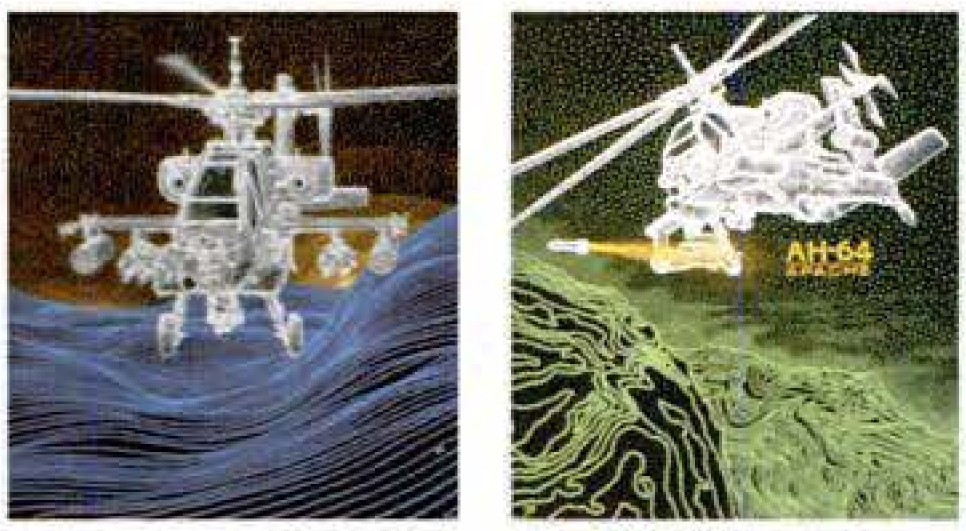
F-15 EAGLE



F-16 TACTICAL FIGHTER

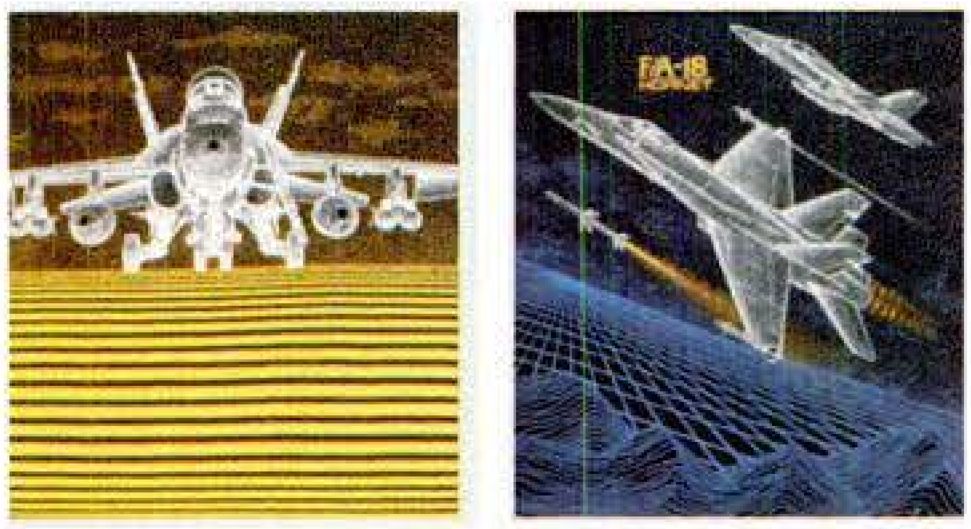


B-1B STRATEGIC BOMBER

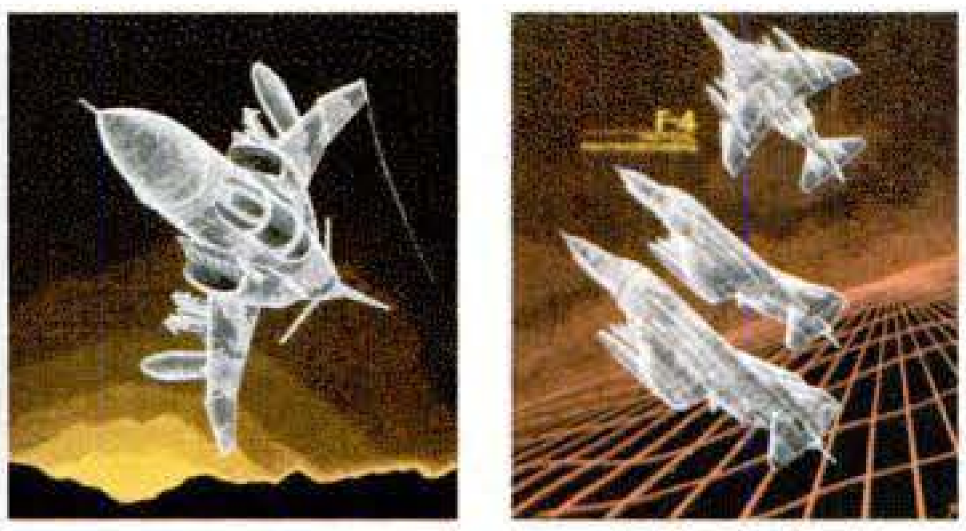


AH-64 APACHE

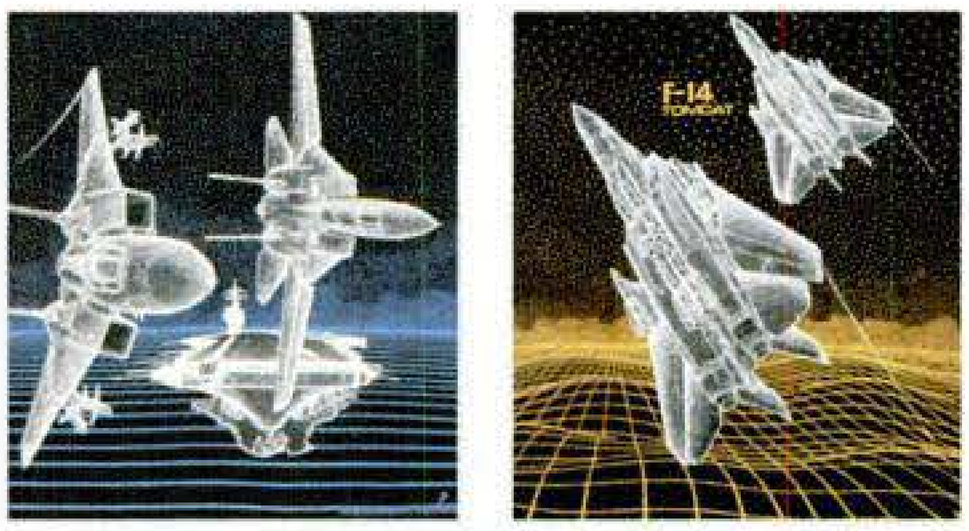
F-20 TIGERSHARK



F-18 HORNET



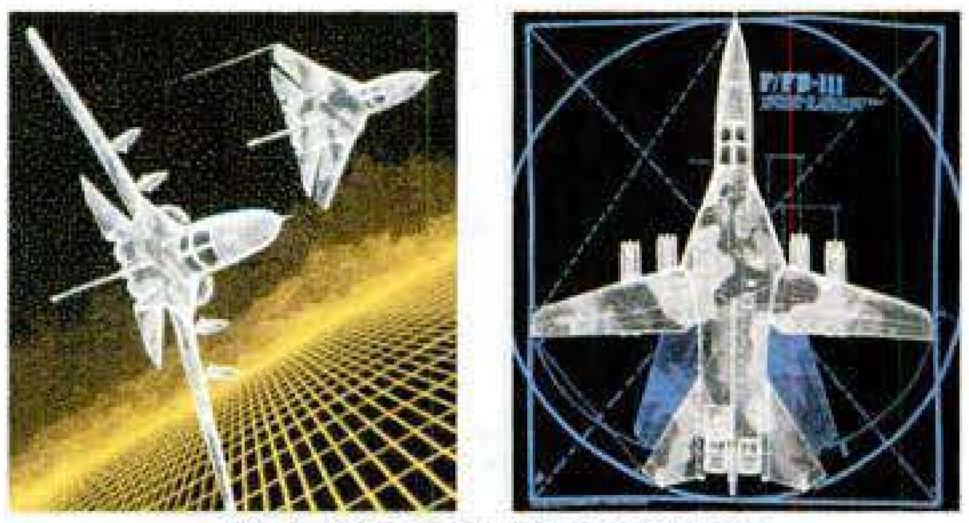
F-4 TACTICAL FIGHTER/BOMBER



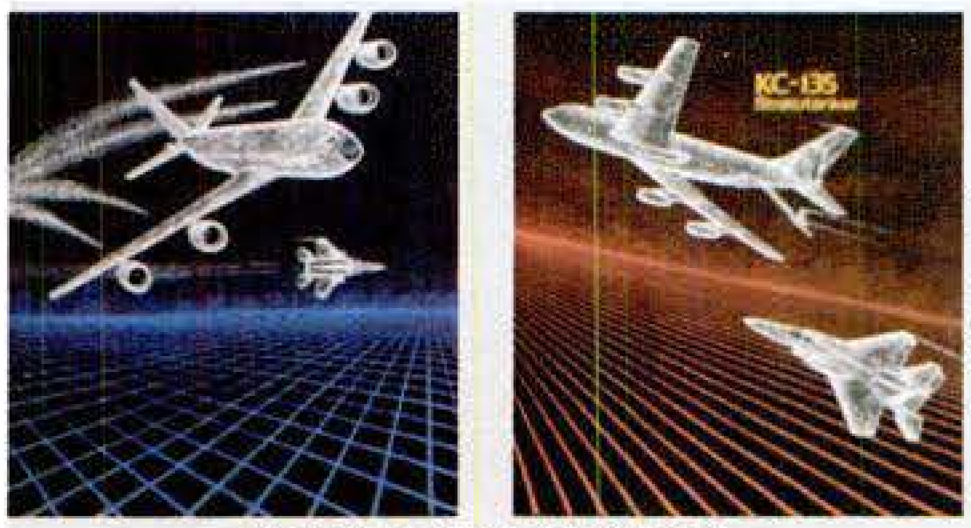
F-14 TOMCAT

A-10 THUNDERBOLT

HARRIER

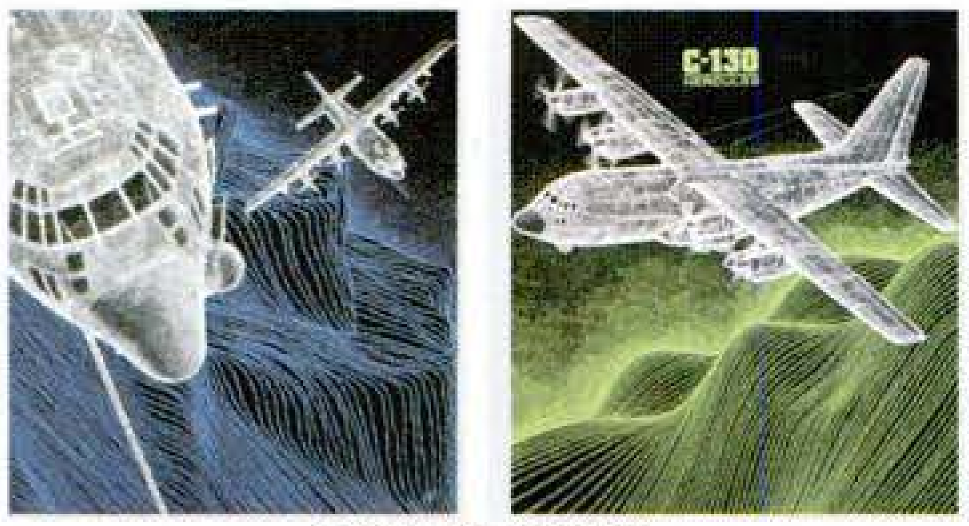


F/FB-111 FIGHTER/BOMBER



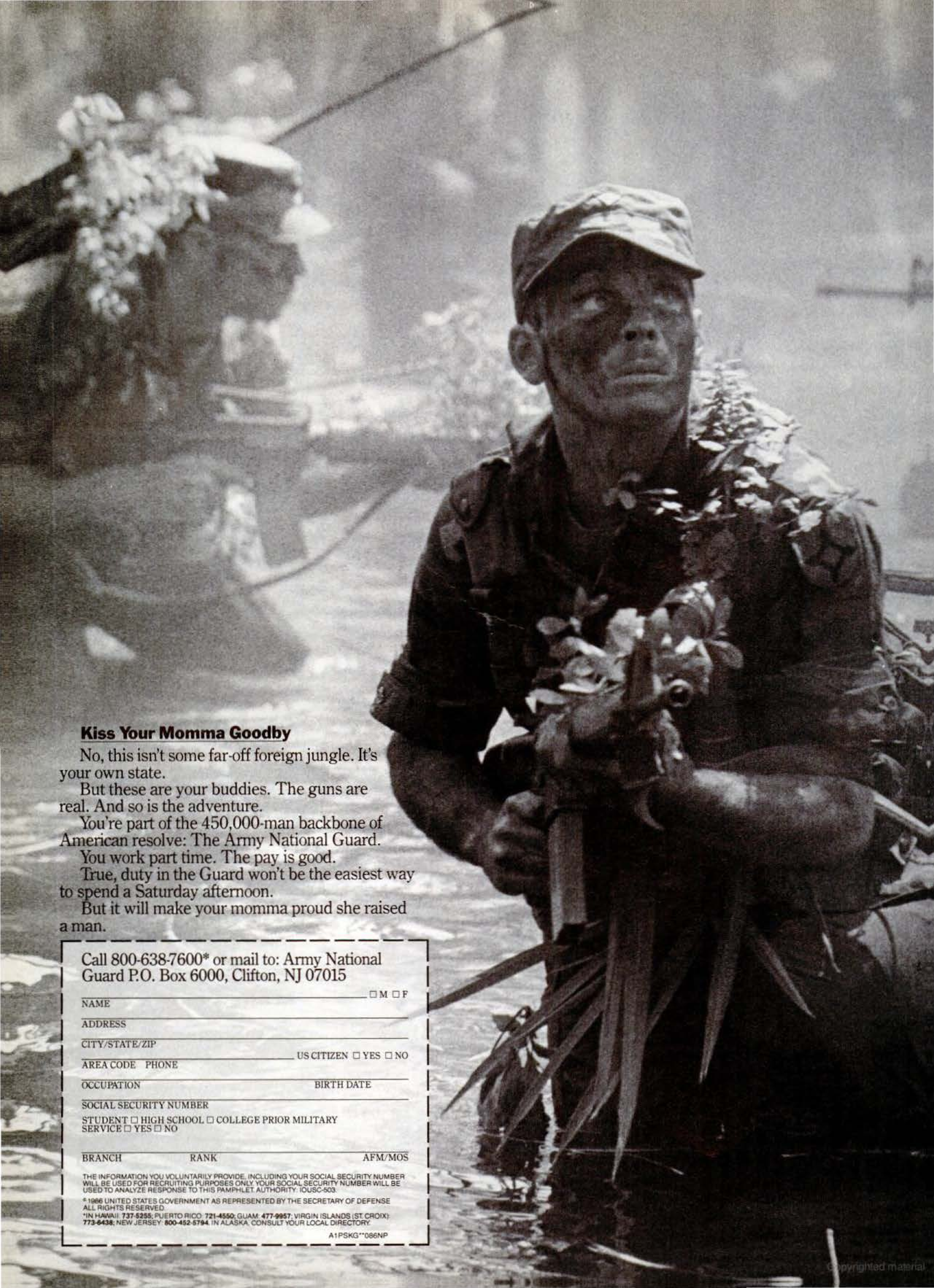
(actual shirt photos)

KC-135 STRATOTANKER



C-130 HERCULES

C-141 STARLIFTER



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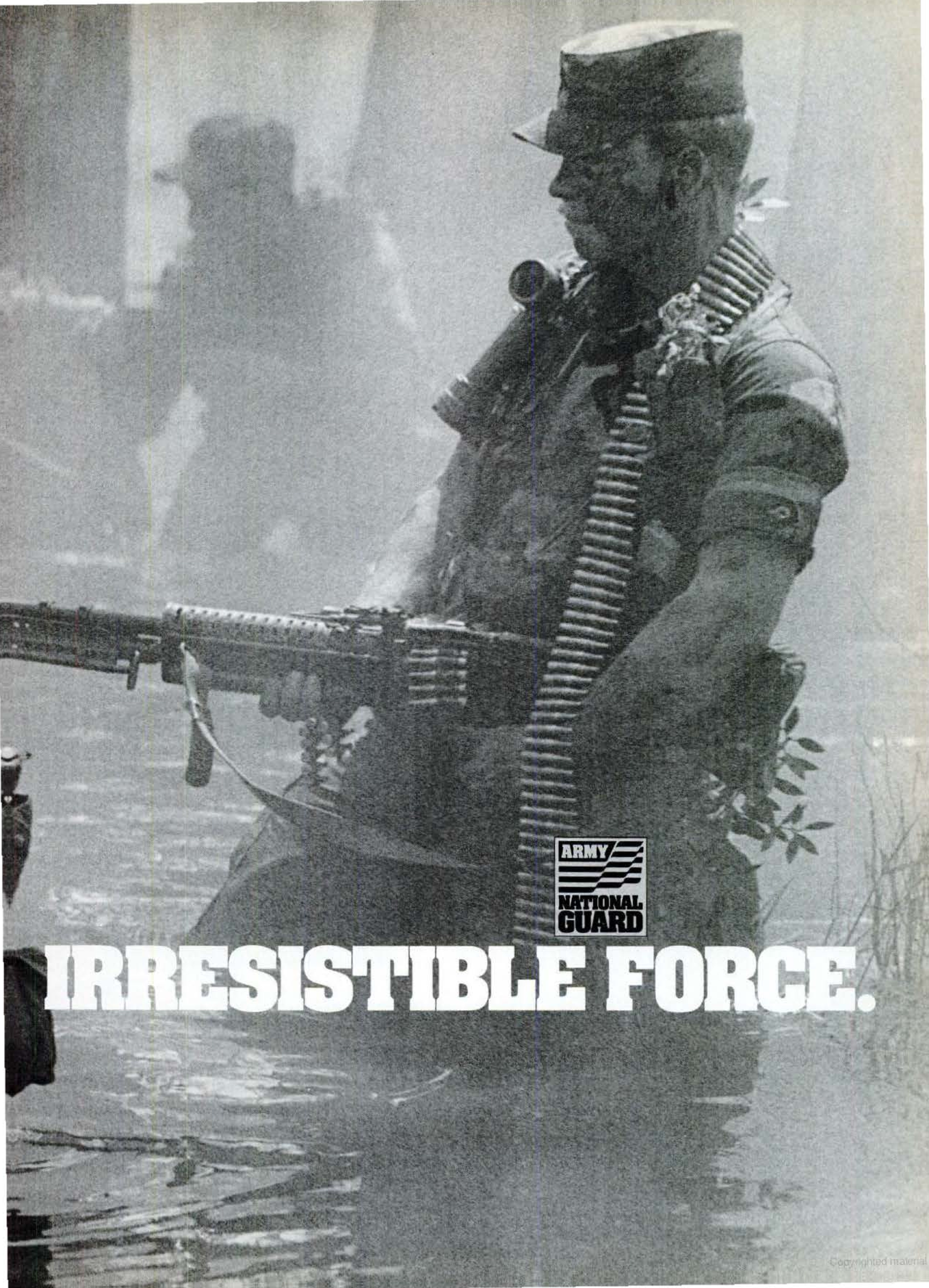
ARMY
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What's New *in Home Improvement*

BY STEVEN ASHLEY

Anti-moth wallcover

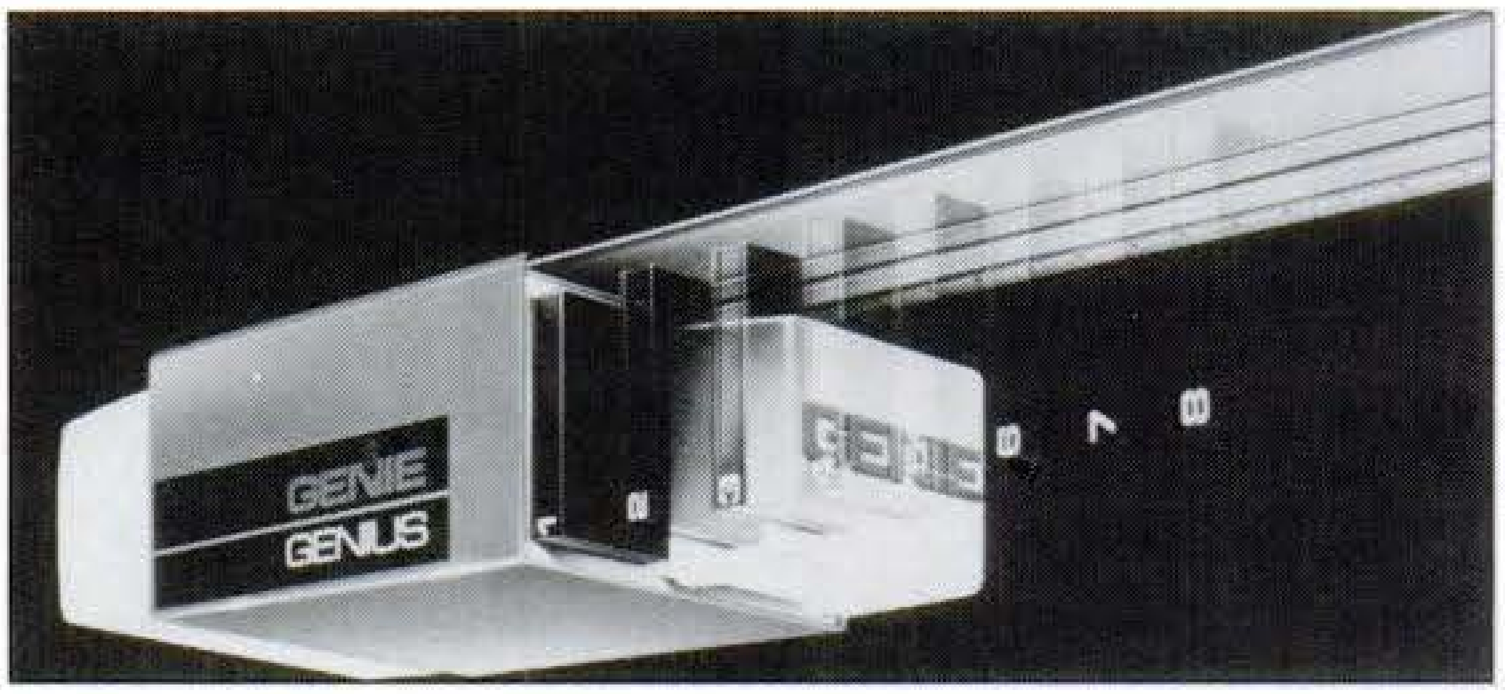
Protect clothes stored in closets from moth damage with Cedar Guard, a vinyl wallcovering that contains cedar oil. The material, which resembles cedar paneling, costs $25 for a 32-sq.-ft. roll. Maker: L.E. Carpenter & Co., 170 N. Main St., Wharton, N.J. 07885.

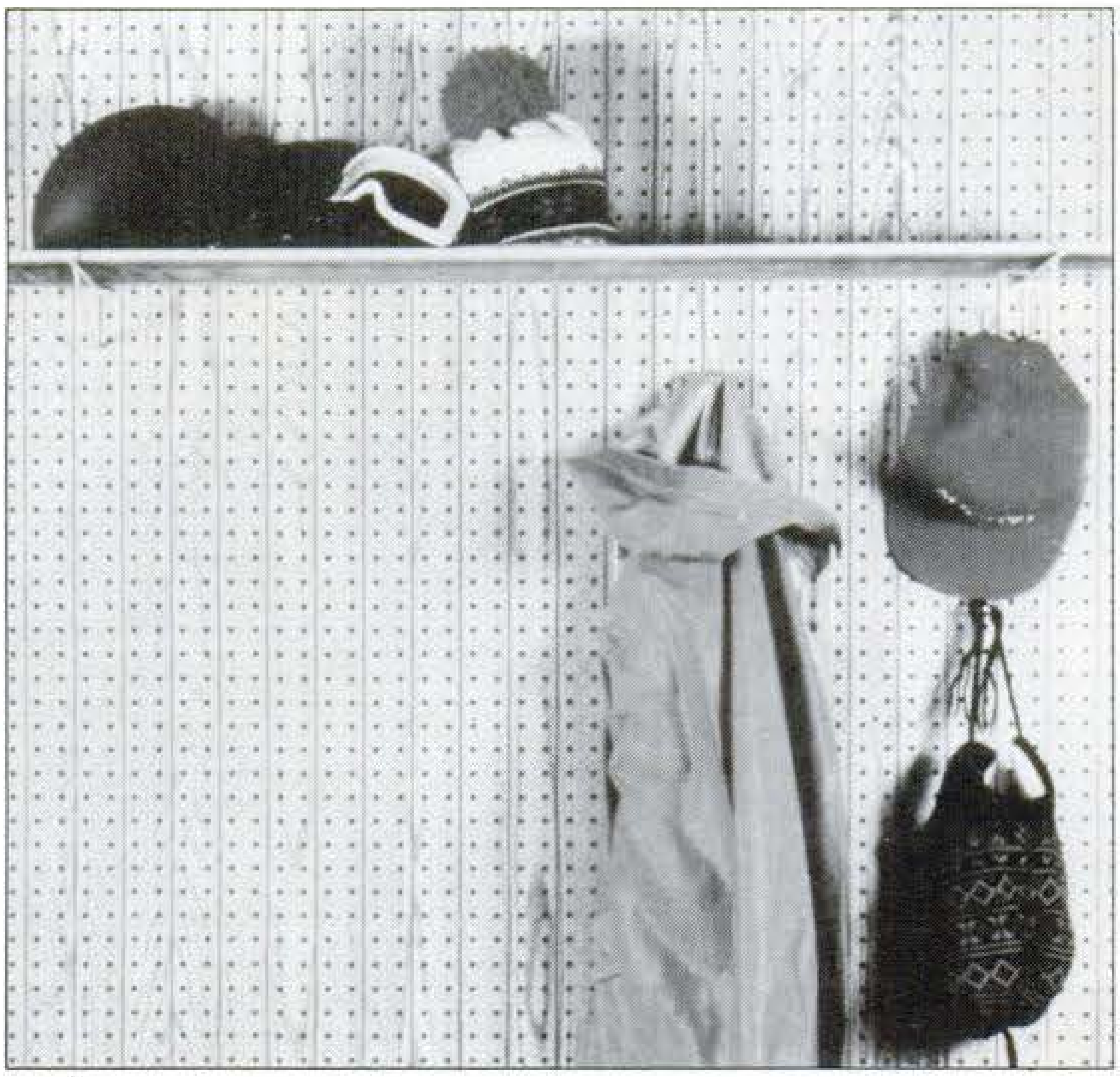
Ceramic cook top

The Combiset KM124 ceramic range from Miele Appliances (12F Worlds Fair Dr., Somerset, N.J. 08873) has variable-size cooking zones to accommodate many different kinds of pots and pans. Safety lights indicate when zones are still hot. The cook top costs $695.

Smart door opener

The $250 Genius garage door opener accepts add-on "brain" modules ($12–$50) that provide such features as an obstacle-detection system, an in-house door control, and a keyless entry system. Genie Home Products, 3040 W. Market St., Akron, Ohio 44313.





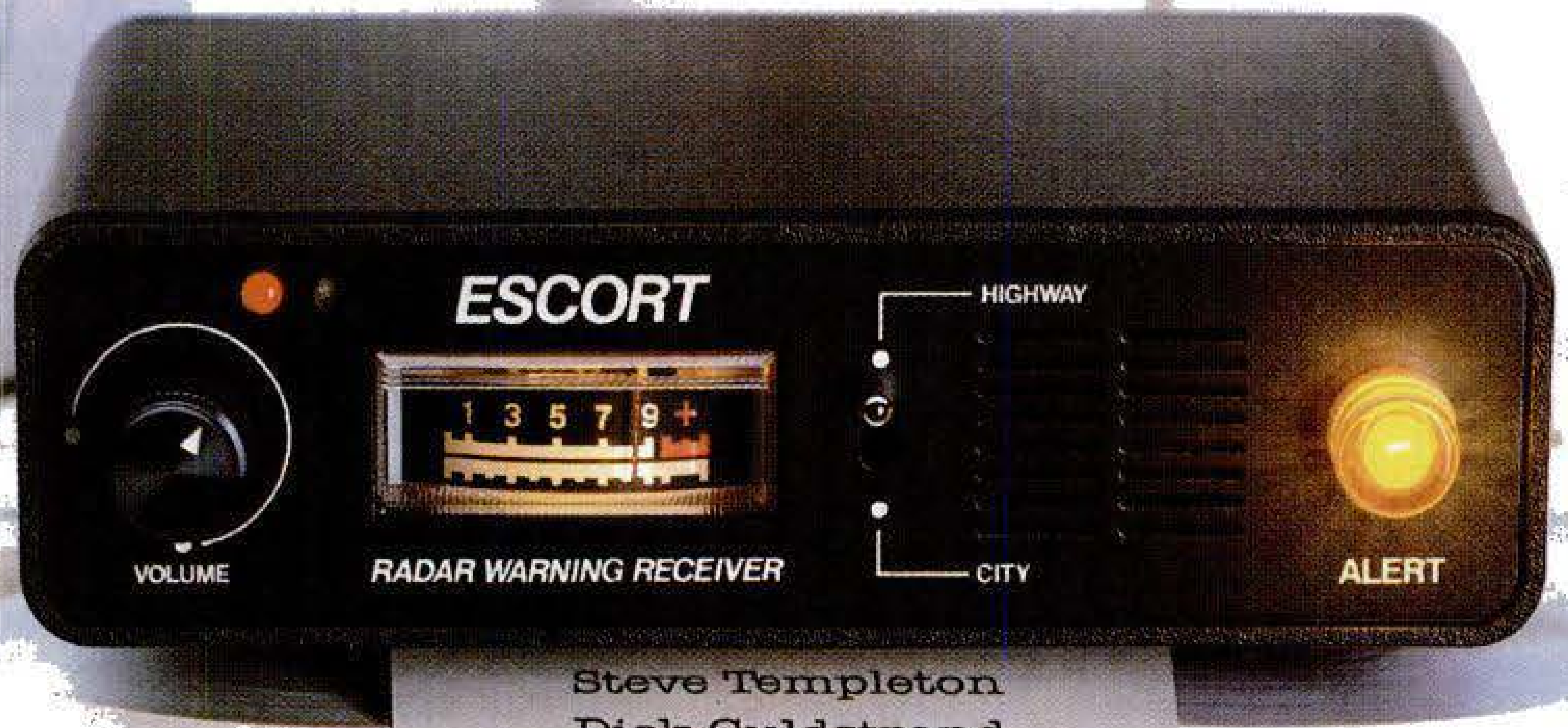
Painted pegboard

Getting a decorator finish on pegboard panels can be difficult: Often wet paint drips from the holes. So Masonite Corp. (29 N. Wacker Dr., Chicago, Ill. 60606) has done the job for you. These 4-by-8-ft. pre-painted hardboard panels ($13) come in hazelnut and chestnut finishes.

Stain test pads

Avoid the hassle involved in choosing a wood stain with these convenient pre-test applicator pads available free wherever Benjamin Moore WoodFinishes stains are sold. Just open the foil pouch and dab a little stain on a test piece. If it's not the color you want, try another.

We can't name everyone who owns an ESCORT, but we can tell you why they do.



Steve Templeton
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Anatoly Arutunof
Rocky Aoki
David Hobbs
Skip Barber
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Chris Mather
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Grayden Obenour
Michael Kranefuss
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We'll bet the first thing our customers will tell you is that ESCORT works. It finds all kinds of radar: X band, K band, over hills, around curves, moving mode, instant-on ambush. Whatever the trap, ESCORT finds it. And this long-range detection is followed up with a full report on the radar's strength. You can read this report on the analog meter. You can hear this report on the audio warning, pulsing slowly when the radar is weak, quicker as it strengthens, then constant as you approach range.

ESCORT even uses a separate warning tone for the two radar frequencies, "beep" for X band, "brap" for K band. The two radars behave differently. Trust ESCORT to keep you informed.

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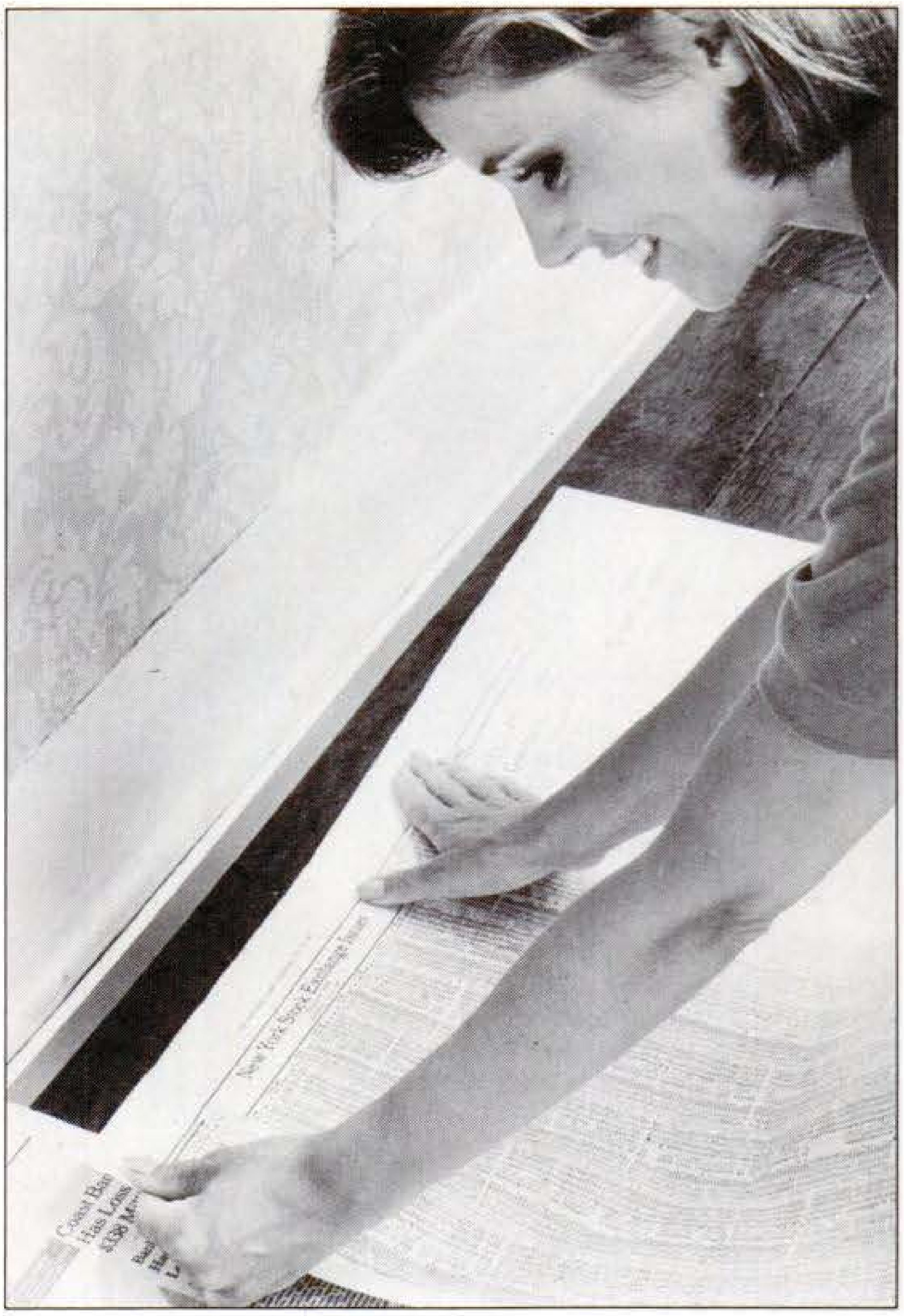
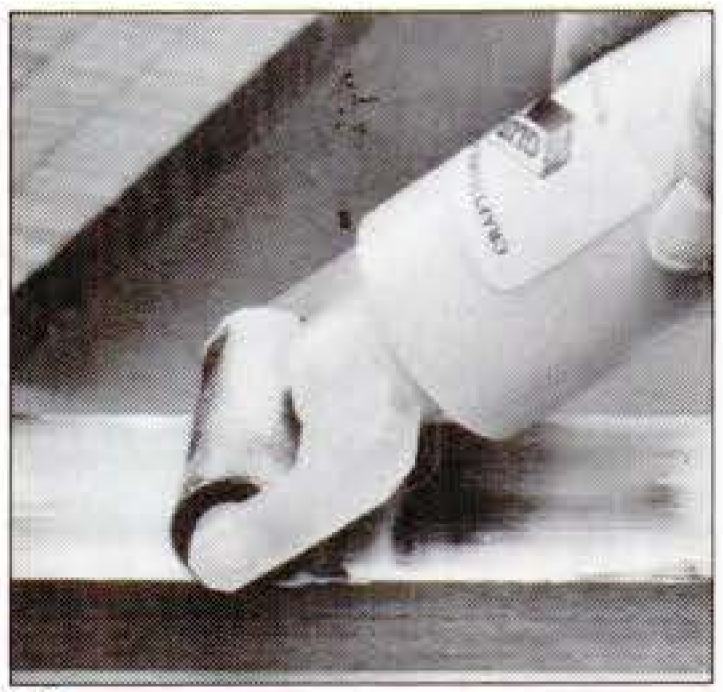
What's New *in Tools*

BY V. ELAINE GILMORE

Masking marvel

One side of this plastic tape has a water-base adhesive guaranteed to peel off cleanly, says Manco (2040 W. 110th St., Cleveland, Ohio 44102). A solvent-base adhesive covers 65% of the other side, to which you attach newspaper or plastic tarp. A 30-yd. roll of Greenline is about $6.



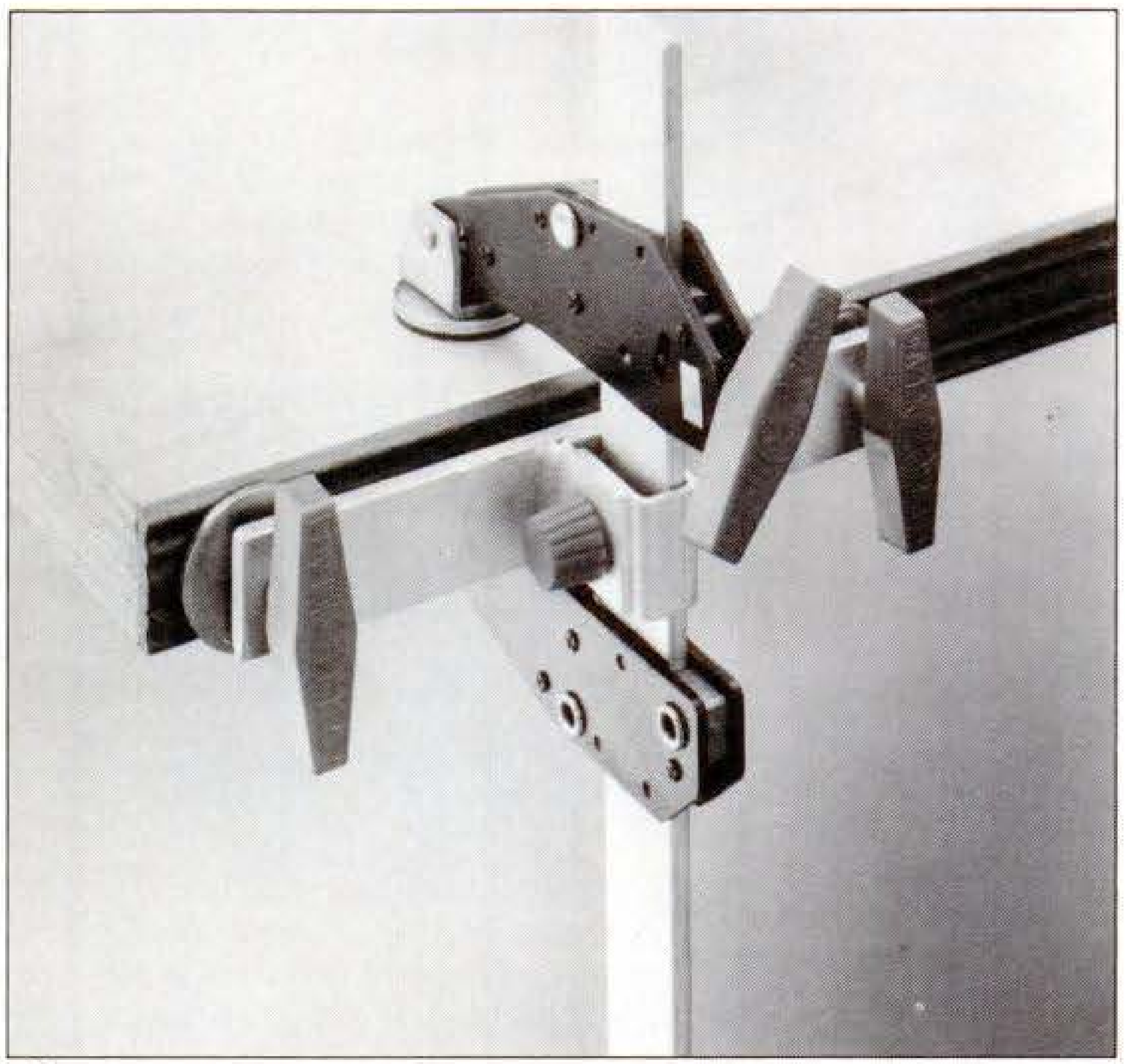


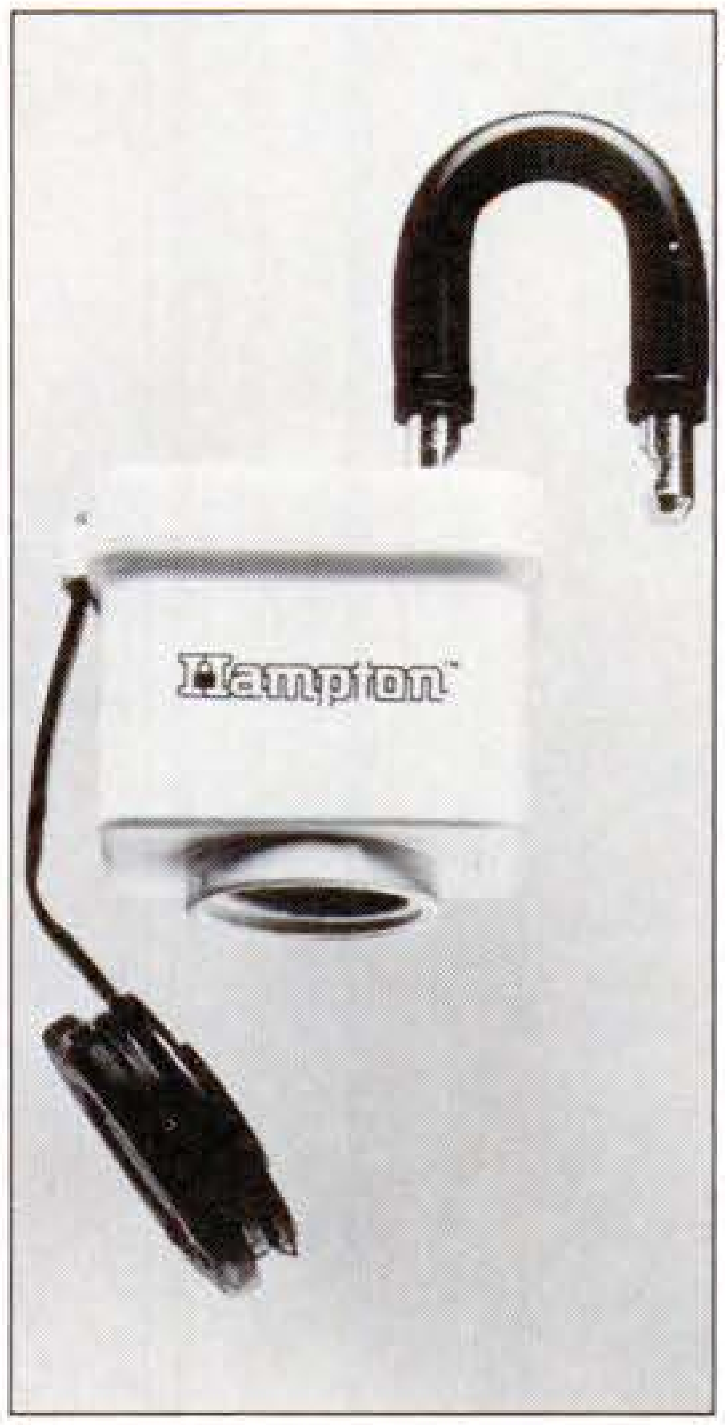
Concrete protection

Thoroglaze, a clear acrylic sealer, halts concrete dusting and seals out stains, says Thoro System Prod. (7800 N.W. 38th St., Miami, Fla. 33166). Use it inside or out on horizontal masonry surfaces. A gallon costs about $17. (For vertical surfaces, there's Thoroclear 777.)

Big spreader

Fill the plastic bottle with glue, screw on the roller head, and squeeze the bottle: Out comes a bead of glue onto the roller. You can spread it—quickly and evenly—on any flat surface, claims Craftmark Prod. (Box 6308, Marietta, Ga. 30065). The Glue Tool is $11.45, ppd.





Protected protection

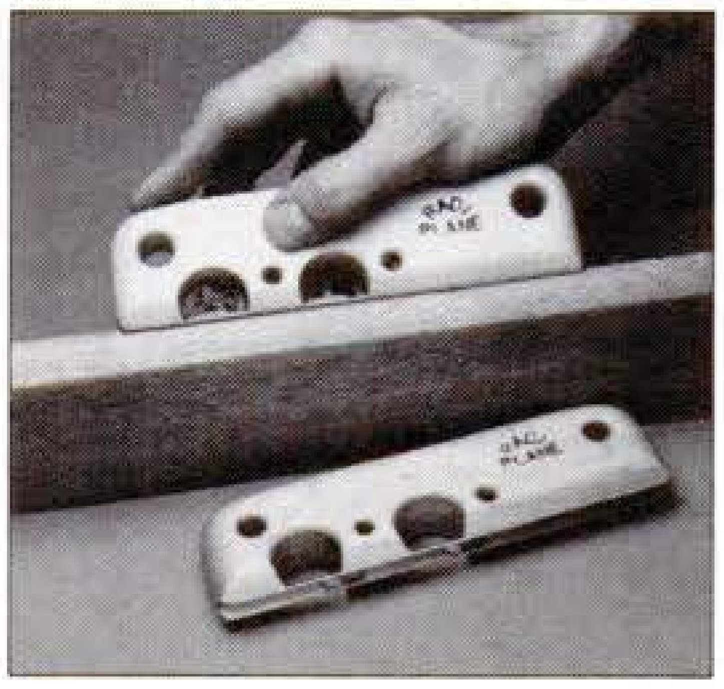
A thermoplastic jacket covers this steel waterproof padlock. A plastic sleeve encases the shackle, and a screw-on lid protects the keyhole. When it's locked, O-rings seal the joints. Hampton Lock Co. (1570 S. Acoma St., Denver, Colo. 80223) makes the locks in many sizes.

Edge clamper

This clamp will put the squeeze on when you're gluing edge moldings and veneers. It starts with a $32 Sylvax Jet Clamp—two movable jaws on a steel bar. Then the Edge Clamp ($21) locks between the jaws. Sylvax Corp., 342 Madison Ave., New York, N.Y. 10017.

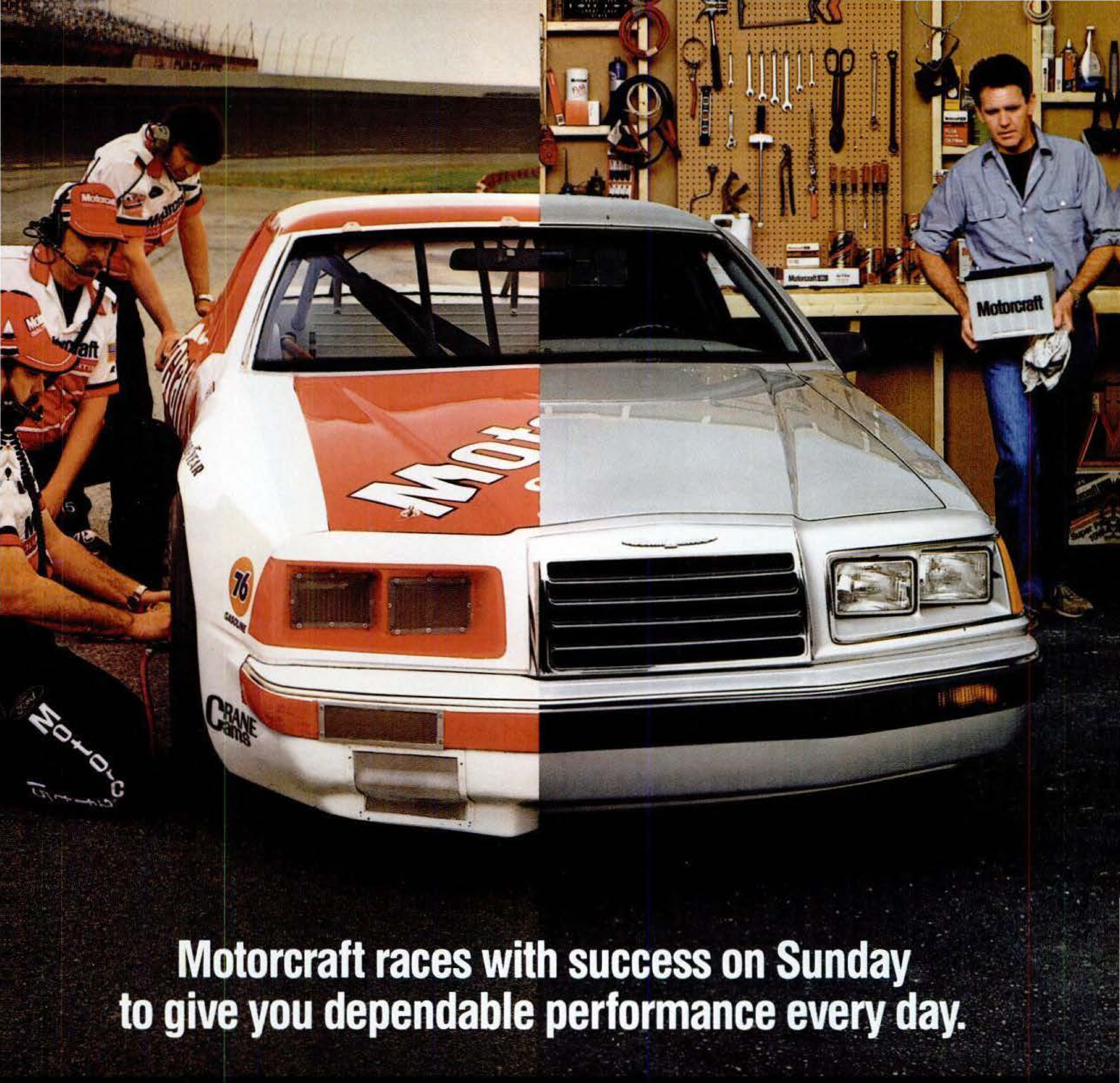
Edge rounder

A board's sharp edges can be quickly and expertly rounded with one pass of the Radi Plane, says Woodcraft Supply (Box 4000, Woburn, Mass. 01888). The solid-maple tool ($21.50 ppd.) has two concave blades: The first makes a shallow cut; the second follows with a deeper cut.



Mini gun

With this tiny glue gun, you'll find it easy to work in tight places, notes Parker Mfg. (149 Washington St., Worcester, Mass. 01613). The Li'l Sticker (about $8) measures only 4 in. but has electronic temperature control for years of reliable service, the maker claims.



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Motorcraft quality parts have been installed as original equipment in more than 35 million Ford, Mercury, Merkur and Lincoln cars and Ford light trucks. But no matter what kind of car or truck you drive, there's only one logical choice. Quality Motorcraft parts from Ford—so you'll know you're getting reliable original-equipment quality replacement parts. Race-proven parts. Trustworthy parts. Motorcraft, of course. Quality parts for all makes of cars and trucks.

Motorcraft from Ford

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The WHAT'S NEW magazine
Popular Science

What's News

The house on this month's cover is not only architecturally spectacular, it is also a striking combination of advanced technical design and outstanding craftsmanship—two things POPULAR SCIENCE readers are in a unique position to appreciate. And it is just one example from a whole portfolio of interesting, innovative homes and home-building techniques that will be found in the special 16-page section appearing in this issue. The cover picture was taken by Jeff Austin.

Return of the prop planes

The new age of propfan airliners, subject of our cover story in March of last year, is now apparently set to dawn in 1992. Boeing plans to use an ultra-high-bypass engine driving counter-rotating props on the 7J7 advanced-technology transport currently under development.

Computers as commodities

The long-predicted personal-computer age may be about to dawn. The product is becoming standard. Makers in the U.S., Japan, Korea, and Taiwan are making IBM clones that have not changed basically since 1981. Prices, which started at $3,500, have hit $1,300 in some markets and, experts predict, will fall below $1,000 by fall. This, some think, will set off another wave of corporate buying and may even trigger the age of personal computers for everyone. Or at least for a lot of people.

But however that works out, it is clear that the cost of computing power continues to fall rapidly.

Fusion fizzle

Over the years, the United States and other countries have poured billions of dollars into the promising, frustrating, maddening, tantalizing quest to produce energy through nuclear fusion. And one of the hopeful approaches has been the Mirror Fusion Test Facility at the Lawrence Livermore National Laboratory. Over the last eight years, $360 million has been sunk into the machine's development.

Recently, 300 dignitaries gathered to attend the machine's formal dedication at its completion. Next year's budget, they were told, will be used to put it into mothballs. Research budgets have shrunk to the point where it cannot be put into operation.

Does it have a future? Perhaps, someday, as part of an international program. "We feel future fusion development is an international responsibility," said John Clarke of the U.S. Department of Energy.

Bad gas revisited

In March, POPULAR SCIENCE published an article revealing that gasoline quality is changing, with detergency going down and volatility going up. And this is causing motorists problems. Now, a General Motors fuel expert—Dr. Wayne France—has told a meeting of the National Petroleum Refiners Assn. to clean up their act. A lot of gasoline doesn't have enough detergency to keep fuel injectors clean, he said, and rising volatility is causing problems both with emissions and summer drivability. He called for nationwide uniform labeling requirements for gasoline.

Geostar launched

The Geostar Corp. [PS, Feb. '84] has just launched stage one of its space communications system. With a relay that went into space aboard the GTE GSTAR II satellite, Geostar will be able to give fleet operators the positions of all of their vehicles at any time and receive messages from the vehicles at headquarters. So far, some 12,000 vehicle transmitters have been ordered for fleet use.

Stage two, with additional relays in space, will offer more services. For example, a user will be able to send and receive messages from his home base at any time. Further, the system will be able to locate him anyplace on Earth with incredible accuracy. That trick is performed by a central computer in New Jersey. It will receive signals from the transmitter as they are received simultaneously by several receivers. It will note the different times at which they arrive, and calculate the position of the transmitter to within a few meters.

Wildcat winner

Buick's advanced new Wildcat concept car, which was seen on the cover of last month's issue, has won the 1986 award for prototypes given by the International Jury of the Car Design Awards Turino-Piemonte. It's the first time an American car has ever won the coveted European award.

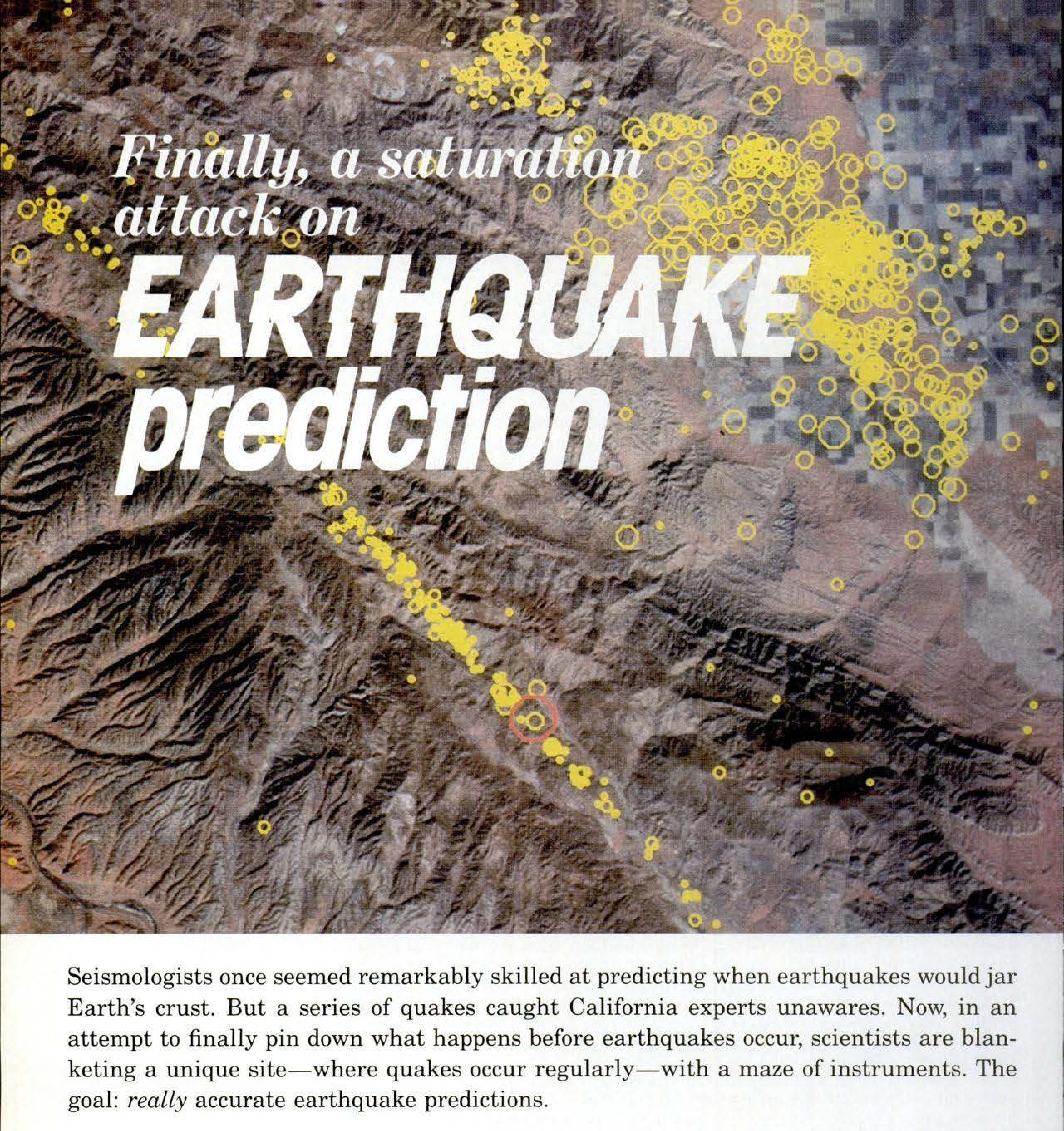
Videotex: a future in the U.S.?

At the moment, not a very bright one, apparently. Several years ago, two giant newspaper companies launched ambitious programs to determine whether people would pay to be able to punch up on their TV screens all kinds of information—from stock quotations to weather forecasts and airline schedules. The companies were Knight-Ridder Newspapers Inc. and Times Mirror Co.—publisher of, among other things, this magazine. Now, $50 million later for Knight-Ridder and $30 million for Times Mirror, both companies have decided to cut their losses. Industry observers say that the future of the technology lies in its use to target small, specific audiences—people who really want home banking, for example. The two publishing companies were after a far broader audience—newspaper readers. And most of them apparently didn't find the service valuable enough to pay for.

CAGilmore

Editor-in-Chief

Finally, a saturation attack on EARTHQUAKE prediction



Seismologists once seemed remarkably skilled at predicting when earthquakes would jar Earth's crust. But a series of quakes caught California experts unawares. Now, in an attempt to finally pin down what happens before earthquakes occur, scientists are blanketing a unique site—where quakes occur regularly—with a maze of instruments. The goal: *really* accurate earthquake predictions.

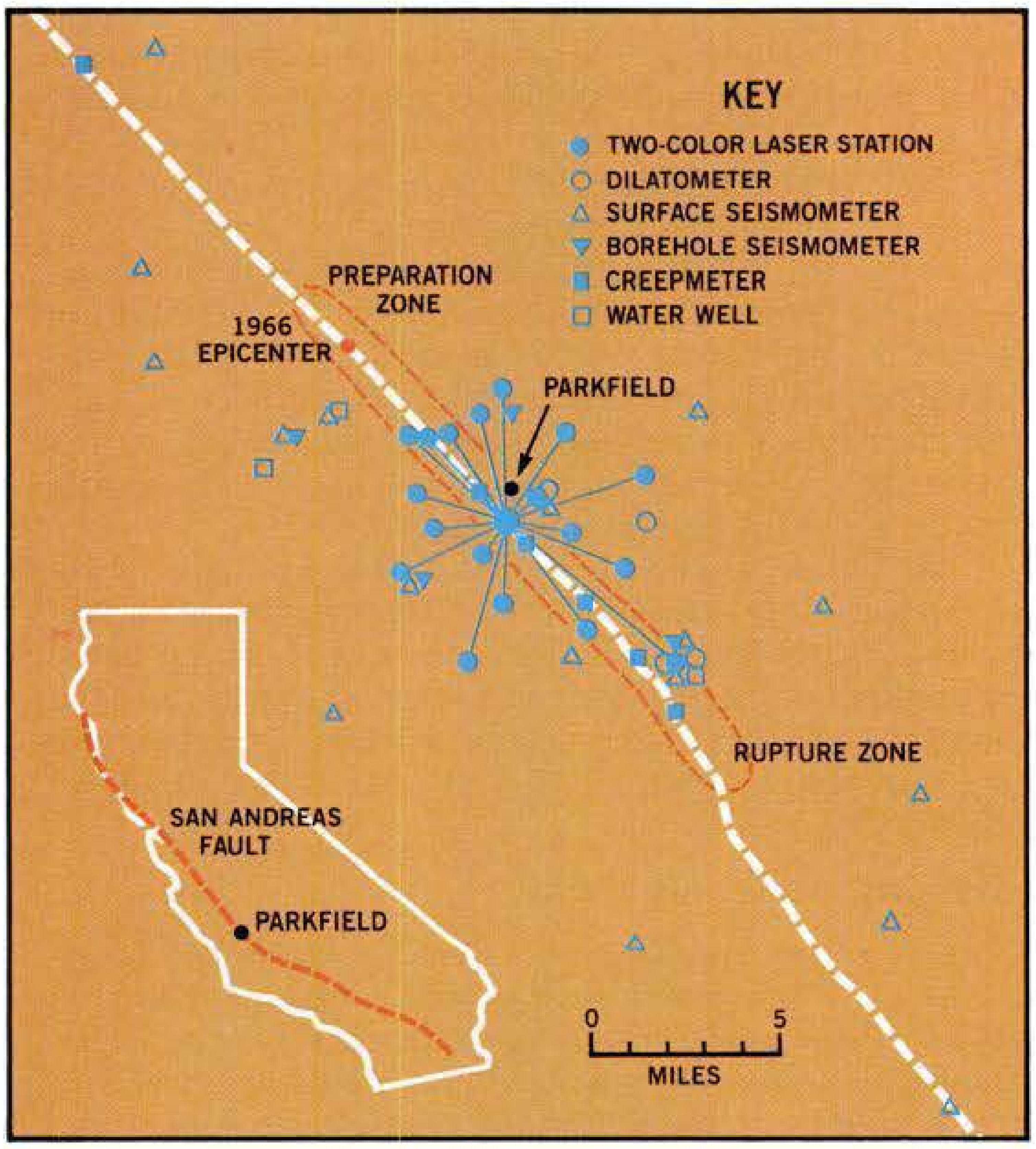
By T. A. HEPPENHEIMER

Winds blow ceaselessly in central California's Cholame Valley. A few flattened green trees stand out sharply against arid yellow-brown hills. The one town in the area is Parkfield, population 34. Even at midday on its main street, the only sound may be a dog barking in the distance. Near an abandoned gas station a rusty pipe trickles water. A sign with skull and bones reads: BAD WATER—DON'T DRINK.

This is earthquake country. The great San Andreas Fault, a break between two of the giant floating slabs that form Earth's crust, cuts directly through the town and on down the valley.

But the Parkfield region is special: Studies show that a 20-mile-long segment of the San Andreas near here may well be the world's most regularly behaved stretch of earthquake fault. Quakes occur in the region on average every 22 years. And the next one, due about 1988, might snowball into the long-feared Big One, a major earthquake that could devastate much of Southern California.

The next Parkfield quake may also provide an elusive key, the target of a long search, that would help seismologists predict future earthquakes. During much of the 1970s, with successful predictions in China, Mexico, and California, experts seemed close to understanding this key. More recently, however, a series of quakes have caught seismologists unawares, showing how little they truly understood



Satellite photo (left) of the Parkfield area in mid-California records epicenters of earthquakes—most small—as yellow dots. The line of epicenters marks the San Andreas Fault. Middle Mountain, where Parkfield quakes begin, is circled in red. The cluster of dots to the northeast are associated with the damaging 1983 Coalinga quake, magnitude 6.5. Earthquakes occur regularly in this area, and seismometer traces have nearly identical patterns for 1922, 1934, and 1966. Anticipating another earthquake about 1988, seismologists are blanketing the area with data-gathering equipment (map above). Recording techniques include leveling and trilateration (distance measurements between three points), seismometer readings, and nightly laser measurements of distance with two laser wavelengths to correct for atmospheric distortion. Strain at specific points is also measured with creepmeters (for slow slippage), dilatometers (similar to liquid-filled balloons), and water-level monitors.

DRAWING BY MITCHELL J. ALBALA

(see box, "Predicting earthquakes: When Mother Nature fooled the experts").

So now, at Parkfield, seismologists are concentrating large numbers of sensors—more than 10 times the number at other sites—needed to monitor possible precursors to earthquakes. They hope to catch an earthquake in action, gathering data that will crack the code needed to predict future quakes.

The difficulty of predicting earthquakes has become more apparent in recent years, just as an understanding of what causes them has developed. An earthquake occurs when the strain between continent-size crustal plates that are locked together becomes too great and they snap apart. If one giant slab rides upward over another, a thrust fault develops; when two plates slip sideways past each other, a strike-slip fault results. Cracks within individual plates also generate quakes.

Most schemes of earthquake prediction are based on a well-known fact: Earthquakes don't just happen all at once. Various parts of a fault slip independently. Computer analysis shows that if a certain slippage takes place far below, it will produce a certain pattern of slippage at the surface. A somewhat more complex procedure, called inverse theory, turns this around: From slippage at the surface you can calculate slippage patterns at great depths. Such surface slippage can be determined by careful distance measurements between reference points near faults. The hope is that measuring movements of faults at the surface will allow seismologists to predict when the earthquake-causing deep slippage is about to take place.

At the U.S. Geological Survey (USGS) near San Francisco, Paul Segall is working along this line. When I visited him, he pulled out a colorful chart marked in patterns of gray, brown, and red. It shows the slippage occurring along the San Andreas Fault around Parkfield down to depths of 12 miles. Such slippages can delay an expected earthquake by releasing strain along the fault. At great depths, where rocks soften in subsurface heat, the chart shows a uniform red, indicating where the fault gives way. But at lesser depths the chart shows a nearly uniform dark color, indicating strain.

"We find that slip at the depths of earthquakes—three to ten kilometers—does not match the surface slip," Segall says. "It's not moving at all. The slip is restricted to a thin surface layer one to two kilometers thick. Below fifteen kilometers the fault slips at thirty-three millimeters per year. Between these depths, it's completely locked." From two to 10 miles down, then, the fault is steadily building up stress and strain, and is not yielding. This means it can be expected to break suddenly, and on schedule, in the next Parkfield quake in 1988.

Seismic creep, the sliding or slipping of rock along a fault, can be measured with an instrument called a creepmeter: Piers on either side of a fault have a wire stretched between them. The wire is weighted on one side to draw it taut. Then, if the wire is pulled by earth movements, a variable resistor attached to one end changes a voltage and registers motion to an accuracy of 0.004 inch.

Strain over a larger area around the San Andreas Fault is now being measured with improved accuracy by comparing changes between fixed reference points. Precisely surveyed geodetic base lines, more than 80 of them at least six miles in length, exist in the area. Some of these base lines have been in place since the 1966 quake, providing a particularly long-term set of data. Older surveys employed surveyors' instruments with an accuracy of 0.4 inch in about six miles. But in recent years laser measurements have been giving tenfold greater accuracy.

In these laser observations, the instruments measure the time photons (light) take as they fly between bench marks. The air along the base line slows their flight—light speed is slower in air than in a vacuum—and the amount of slowing depends on weather conditions like temperature and pressure. Thus, when laser surveying is underway, an airplane flies along the base line to make weather observations, used to calculate a distance correction.

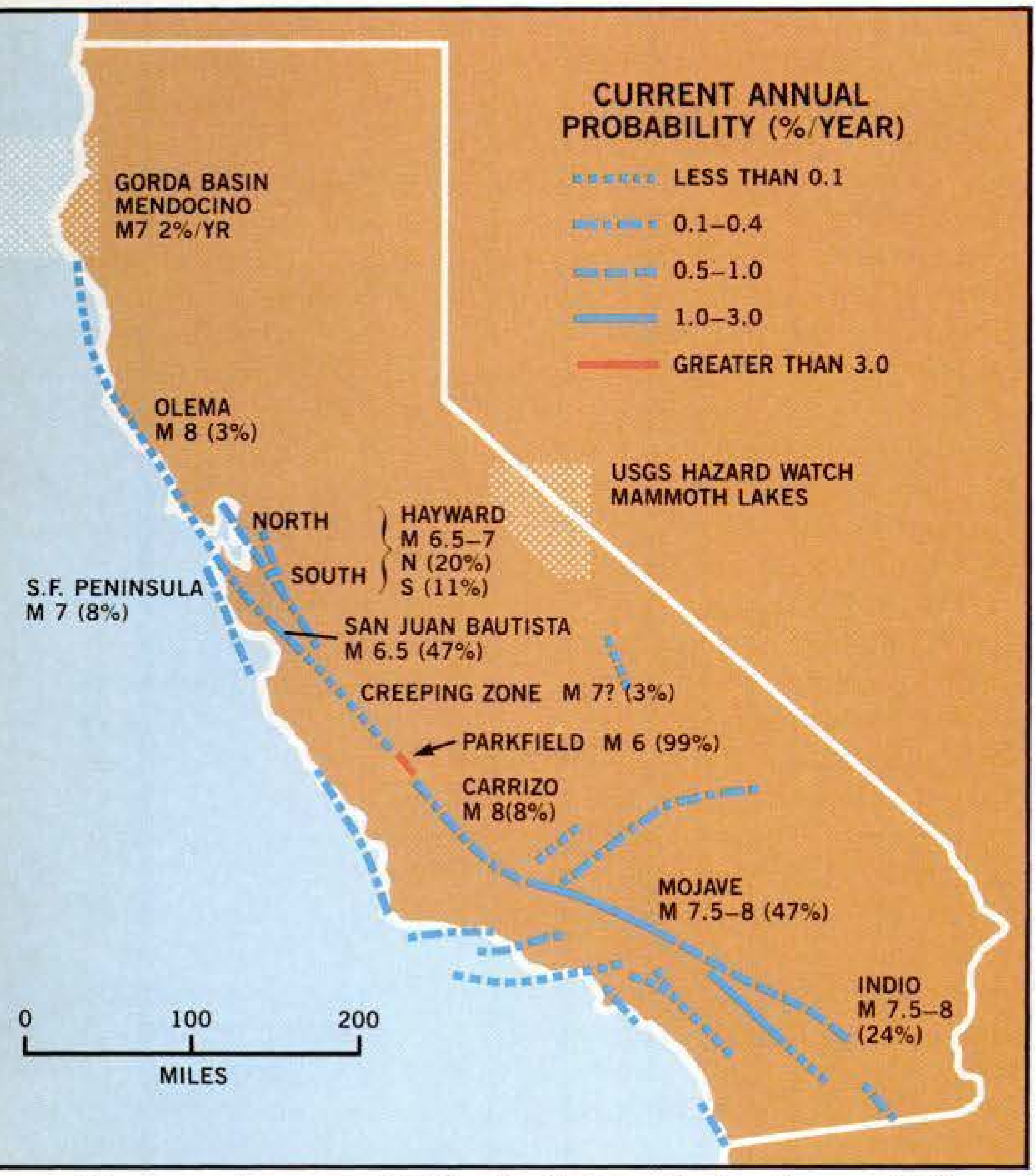
This is a somewhat inconvenient arrangement, however. As a result, the lines are surveyed in this fashion only once a year. But a new technique, now coming into widespread use, allows surveys to be made every night. For this, the laser-ranging measurements are carried out with two lasers, each operating at different wavelengths with red and blue light. The atmosphere produces measurably different amounts of slowing at the two wavelengths, so the necessary correction can be found immediately.

The finger of God

In the Parkfield area, the only instrument readings that are dramatic or noteworthy take place when the local laser-tender goes to work. He is Duane Hamann, the teacher in the Parkfield elementary school, one of the few one-room schoolhouses left in the state. Hamann runs the two-color laser, swiveling it around like a naval deck gun. He points

Continued

Look out, California: Earthquakes ahead



DRAWING BY MITCHELL J. ALBALA

Earthquake probabilities in California for the next 30 yrs. (and annually), prepared by USGS's Allan Lindh, shows that along the Mojave stretch of the San Andreas Fault, in Southern California, there is a 47% chance of a quake of magnitude 7.5–8. Key (top) indicates the annual probabilities.

it at each of 15 reflectors set up in faraway hillsides and fields, sighting carefully as he watches for the strong reflection that shows his beams have found their target and are measuring its distance, accurate to a millimeter in 10 kilometers (0.04 inch in six miles). These are the precise surveys that Segall relies on to determine with his computer what the fault is up to far below.

At night, the red and blue laser colors form a strong, well-focused beam. If you look over to a hill, you'll see a tiny spot of light. Move your head six inches, cutting the reflected beam, and you see a dazzling, brilliant iridescence of red and blue. The reflected beam is that sharp. In the words of the USGS's Allan Lindh, a key figure in the Parkfield project, "It's like the finger of God."

But earthquake experts have traditionally relied on more than surface-slippage measurements for earthquake predictions. During the mid-1970s, for example, they based their predictions on precursors, or warnings, that included changes in the earth's magnetic field, tilting and elevation changes of the ground, small tremors, and water-level changes.

Searching for good rocks

Because seismologists cannot directly probe the faults miles below where earthquakes take place, instruments useful for prediction must be extremely sensitive. At Parkfield, the researchers are using a great variety of sensors to gather data that will aid in predictions. Among the most important is a type resembling an oil-filled balloon, known as a dilatometer. It measures tiny strains in the subsurface rock, which squeezes the instrument to produce measurable pressure changes.

Installing such an instrument closer to where the compression takes place provides better readings. Sometimes it's necessary to drill a hole hundreds of feet deep. "We look for good rocks," explains Lindh. "Those are rocks that when you drill a hole in them, the hole stays open. When you drill close to the San Andreas, the rocks are very seriously degraded. Lots of times you drill a hole, pull out the

Predicting earthquakes: When Mother Nature fooled the experts

Can earthquakes be predicted, as are hurricanes? Can timely warnings be given, days or at least hours in advance? Some years ago, about the time the movie *Earthquake* appeared, prediction successes made seismologists and other experts optimistic.

In October 1974, for example, geologists noted a rise in the earth's magnetic field near Hollister, Calif. Such magnetic changes had been discussed as possible earthquake precursors. The increase lasted for about one month, then returned to normal. At the same time, instruments showed changes in the land tilt, another possible precursor.

Thanksgiving quake

These incidents drew the attention of geologists at a meeting of the Pick and Hammer Club on a Tuesday night late in November. Some experts at the meeting suggested an earthquake would occur at Hollister the following day. Their prediction proved surprisingly accurate, although the quake hit one day later, on Thanksgiving. It struck about 10 miles north of Hollister, registering 5.2 on the Richter scale.

Next, early in February 1975, the Chinese achieved a prediction success. Near Hai-ch'eng, northeast of Peking, they tracked a long list of precursors to earthquakes. These included patterns of small earthquakes and changes in ground tilt, water levels in wells, and the earth's magnetic field. Chinese observers also emphasized unusual animal behavior, such as snakes crawling out of the ground in winter.

Then on Feb. 3 a swarm of small and moderate tremors struck in quick succession. Based on the earlier data, the authorities declared these were foreshocks and warned people to evacuate. A few hours later an earthquake of magnitude 7.3 destroyed or damaged 90 percent of the city's buildings. The timely warning saved thousands of lives.

In 1976, near the city of Tang-shan in China, observers watched a similar series of precursors unfold. But these events petered out, leaving no clear path to a prediction. Then a magnitude 7.8 quake struck without warning, killing 240,000 people. With this, a general panic spread throughout the country, and millions of Chinese people lived outdoors that summer. Every province issued an earthquake prediction, more in fear than from evidence. Evaluation teams then retracted all the predictions except one. An anticipated quake near Songpan, in the west of China near Tibet, deserved closer scrutiny.

Songpan prediction

There had been a swarm of earthquakes in the area, some as large as magnitude 5. In June, at a meeting of the provincial seismological bureau, experts predicted a Songpan quake for the second half of the year. On Aug. 12, the bureau issued an imminent prediction for an earthquake of magnitude 7 or greater "within a very short period of time." The quake—magnitude 7.2—struck on Aug. 16 only 30 miles from the expected location.

Meanwhile, halfway around the world, seismologists studying data from Oaxaca, on Mexico's west coast, discovered the area had been ominously quiet for some time, suggesting the calm before a storm. In 1977, three seismologists forecast that an earthquake of magnitude 7.5 or larger would strike the area within the next few years. In August 1978, at the University of Mexico, Lautaro Ponce found that small quakes had occurred in the area; a big one seemed imminent. He soon caught the interest of Karen McNally of the California Institute of Technology, who arranged to spend November studying small quakes in the drill stem—and the hole collapses. The good rocks stay open long enough to let you get an instrument in."

It's also important to anchor a dilatometer in place. "We lower down a bucket of cement and dump it in a puddle at the bottom of the hole," says Lindh. "Then, very rapidly, we bring the bucket back out and run the instrument down. You have to lower a $20,000 instrument on a cable, with a quarter-inch clearance. It settles in very gently and is cemented in place."

With this technique, Lindh's colleagues today are measuring strains within the fault at Parkfield to an accuracy of one part in a billion, helping to map the action of the fault at much greater depths. Over short periods of time the accuracy is 100 times greater. Indeed, the earth itself calibrates the instrument through its twice-daily flexing under the pull of the sun and moon. These "earth tides" produce strains in the solid earth, 10 parts in a billion. They thus readily show up in the data.

Can measurements like these provide the clues to why seismologists have failed to predict earthquakes? Wayne Thatcher of the USGS, who directs work at the Parkfield site, believes the recent series of California quakes came as a surprise because 10 to 100 times more instruments would have been needed at each site to predict them. The few creepmeters or precisely surveyed base lines to register slight shifts on the surface just aren't enough. Many more readings are needed so computer programs can calculate motions at great depths based on surface strain and other measurements, Thatcher says. Also, none of the California sites that eluded earthquake predictions earlier had instruments placed deep within boreholes to monitor the fault's behavior hundreds of feet down.

Why are the experts concentrating only on Parkfield? With many active faults, limited funds, and few experienced seismology teams, the USGS in California had to focus its effort, putting many of its eggs into the basket of one stretch of fault. Picking that appropriate stretch, however, is the same as predicting an earthquake in the first place. What results is a Catch-22: Before they can learn to predict quakes by running an experiment with a dense instrument array, they first must predict a quake to choose the proper location as a place for that array.

The San Andreas Fault near Parkfield solves this paradox through its happy property of regularly breaking in a moderate-size earthquake. It broke in this fashion in 1857, 1881, 1901, 1922, 1934, and 1966. The 1934 quake came 10 years early, but the 1966 tremor reestablished the sequence.

Matching earthquakes

Although the Parkfield quakes have occurred regularly for more than a century, their pattern has been recognized only recently. At the USGS, William Bakun made the key findings that indicated this regularity of earthquakes in the area. "I was working with Tom McEvilly of Berkeley," Bakun recalls. Both Bakun and McEvilly had set out seismographs near Parkfield just after the 1966 earthquake. "Always the best data kept coming from Parkfield," he continues. "We had good data from the 1934 and 1966 quakes. Could the 1922 event give a third member of the set? We wrote to seismic stations that had the needed data. And when we got the data together, we realized the quakes were the same size: magnitude 5.6." Moreover, the 1934 and 1966 quakes had been preceded by strong, nearly identical foreshocks 17 minutes before the main shocks. This was convincing evidence that the quakes were really repeating.

That finding came in 1980. Already, beginning in 1978, Bakun's colleague, Allan Lindh, had been urging the USGS to concentrate on the Parkfield area. An angry dispute had triggered Lindh's proposal: "There was a USGS meeting to review the year's work, and plans for the future," Lindh recalls. "Being a really obnoxious person, I told them very bluntly what I thought of it. And one of them got very angry. He stood up and said if I was so smart why didn't I think of something better to do? I called him a few names and stomped out; then I came back to my office and did just that."

Continued

Oaxaca region. McNally and Ponce thus were on the scene on Nov. 28 when a shock of magnitude 7.8 rocked the area—just 30 miles closer to the coast than forecast.

These were the successes, the predictions or near-predictions that offered hope. But beginning in 1979 in California, amid well-instrumented networks featuring seismometers and other equipment, a series of moderate-size quakes struck in succession without warning. These events clearly showed that much remained to be learned in the field of earthquake prediction.

Moreover, at least one theory about earthquakes that seemed to promise prediction results fell apart when challenged. This dilatancy theory, originally based on observations of stressing rocks in a laboratory, held that rocks within earthquake zones develop millions of tiny cracks as pressure develops. Water seeping into these cracks causes the rocks to dilate, or expand, said the theory. And scientists have claimed that measuring changes in the velocity of seismic waves passing through these rocks offers clues that an earthquake is pending.

But researchers at the University of California at Berkeley devised what amounted to a controlled test of the theory: Seismic records produced by blasts in rock quarries in an earthquake region gave locations, times, and magnitudes. Why not compare the velocities of these seismic waves where they had passed through earthquake zones before and after the quakes occurred? This comparison proved the theory wrong, at least in the rocks near California's San Andreas Fault, because the velocities did not change significantly.

One of the first unanticipated California earthquakes occurred on Aug. 6, 1979. A tremor of magnitude 5.7 hit near Coyote Lake, 60 miles southeast of San Francisco. It fell on an offshoot of the San Andreas Fault, within a network of monitoring instruments. "We were clearly not overwhelmed by short-term precursors," said Robert Wesson of the U.S. Geological Survey. No foreshocks occurred. And no tilts in the earth's surface or changes in magnetic fields occurred.

On Oct. 15 of that year, a tremor of magnitude 6.6 struck California's Imperial Valley, close to the Mexico border. Clarence Allen of Caltech had installed instruments across the fault involved. But as Allen recalls, "we have a good record of what was happening before the quake, and there's not a clue that anything strange was going on."

On May 2, 1983, in central California, the town of Coalinga suffered heavy damage from a magnitude 6.5 earthquake. This one fell within a seismic pattern known as a Mogi doughnut, after Kiyoo Mogi of Tokyo University. A Mogi doughnut is a ring of moderate-size quakes surrounding a zone with few or no quakes of any size. Eventually a large earthquake breaks in the middle of the ring.

Coalinga doughnut

At Coalinga the doughnut began to form in 1975, when a pattern of magnitude 4 and 5 quakes started to circle the town. But no foreshocks greater than magnitude 1.5—too faint to feel—occurred. Says Clarence Allen: "If you had asked any seismologist the day before that quake what was the most likely place for a magnitude 6.5 event, I don't think any of them would have picked Coalinga." He sighs at my mention of Mogi doughnuts and says, "There are so many of them that we haven't learned how to make use of them."

Then, on April 24, 1984, a tremor of magnitude 6.1 struck east of San Jose, with the greatest damage occurring in the town of Morgan Hill. It fell within a net of USGS instruments; and again no useful precursors registered. A geodetic base line straddled the fault. Its 19-mile length had been measured repeatedly since 1981, to an accuracy of 0.3 inch; these measurements also failed to indicate anything unusual.—T. A. H.

A solar-powered radio at a Parkfield site beams data about magnetic-field variations to a distant receiving station.

Lindh proposed that the USGS should concentrate its efforts at Parkfield, because he had studied Parkfield's earthquakes as a graduate student. "I knew quite a bit about it," he explains, "so naturally I took the place I knew about. And thanks to the work of Bakun and McEvilly, quite a bit of information existed." Then, after winning support of USGS senior director Barry Raleigh, Lindh began building a consensus among other seismologists.

Earthquake mountain

The USGS researchers Lindh convinced have a good idea how the 1988 quake they're expecting will develop. In fact, from experience with past Parkfield tremors, it's possible to give a detailed scenario.

The key point to watch will be a rise in the hilly area to the north, known as Middle Mountain. Thatcher describes it as the "preparation zone," the place where earthquakes begin. Close by, notes Lindh, small shocks have been striking every 39 to 41 months since 1971, almost as if it was a clock ticking. The last one, magnitude 3, took place in May 1985. The next is due in August 1988 and could be the trigger that sets off the main earthquake.

When a tremor hits along a small stretch of fault, it relieves some of the built-up stress along that stretch, but passes the stress onward, further loading other fault sections. Thus, such a small quake could give the final push to the tightly strained rocks in the preparation zone, triggering a larger quake. That would be a repeat of the 1934 and 1966 foreshocks, magnitude 5.1.

Both in the Parkfield area and throughout the rest of California, the USGS's seismometers are connected by phone lines to a computer system. Its calculations would quickly pick out the newest and strongest shakings, providing the magnitude and location, and display this data on terminals. From its similarity to the 1934 and 1966 foreshocks, it could then be recognized immediately as a warning that the next Parkfield main shock is perhaps 17 minutes away.

Seventeen minutes after the foreshock, the main quake of magnitude 5.6 will begin. A small patch of locked fault some two miles deep will slip under the load of that recent foreshock. The slipping will spread and widen as rocks on either side of the fault, strained beyond what they can bear, slip past each other, grinding one another violently amid the pressure deep in the earth. A wave of sliding will race outward from the epicenter, the starting point of the quake, traveling along the fault at speeds of about two miles per second. Wherever this wave reaches, tightly locked rocks will loosen and slip, adding their energy to that of the building earthquake.

The shocks from this latest quake will strike with considerable force at the surface. Chimneys and water tanks may topple; some walls may crack; a pipeline or two may rupture. Fortunately, the damage will be minor, for Parkfield is remote from any city, and the area's sturdy wood-frame homes stand up well even to severe shaking.

The break in the fault will begin in the northwest and spread quickly to the southeast, in the direction of Los Angeles. About five miles northwest of Parkfield, the fault bends by five degrees, and that may be enough to stop the break there. Farther northwest, the fault carries little or no strain at all. It is creeping, slowly and continually deforming, thus preventing the buildup of strain that could bring a great earthquake. This creeping section cuts the San Andreas Fault into two parts, isolating San Francisco from any possibility that the Parkfield quake could spread in its direction. But Los Angeles may not be so fortunate.

If the 1988 earthquake is a typical one, it will break the fault only over a distance of about 20 miles. At that distance from Middle Mountain is another rise, Gold Hill. Here the San Andreas sidesteps like a freeway detour, and is offset from a straight line by about two miles. This offset is ordinarily enough to bring the fault-line rupture to a halt, ending the quake. But it is just possible that the 1988 affair will not be an ordinary tremor.

"A problem that has bothered seismologists is how earthquakes stop," says Bakun. There appear to be barriers along the fault line to stop them, like the bend and offset in the San Andreas Fault near Parkfield. But a big quake can gather momentum and break through the barriers. "It gets up a head of steam," Bakun explains. If this happens, it could bring the long-feared Big One, the major earthquake that may devastate much of Southern California.

The last such great quake, magnitude 8.3, struck in 1857. It ruptured the San Andreas Fault from Parkfield to San Bernardino, a distance of some 200 miles. The severity of the 1857 quake fully matched the 1906 San Francisco quake, which left that city abandoned to fire and ruin. At the California Institute of Technology, seismologist Kerry Sieh believes that a moderate-size Parkfield earthquake triggered the 1857 cataclysm. "Perhaps it was a Parkfield quake that got away," is how Bakun describes it.

Sieh has shown that in Southern California the San Andreas Fault has experienced such great earthquakes every 145 years, on average; and the 1857 quake occurred 129 years ago, much too close for comfort. He estimates a 70 percent chance of such a quake occurring before 2036.

Two federal agencies have issued reports describing the potential damage. Most California dwellings are of wood-frame construction and stand up well to shaking. Still, if a great earthquake hits at 2:30 a.m., when people are at home in bed, 3,000 may die. If the Big One strikes at 2 p.m., when many people are downtown, 11,000 could die.

Some day all this will happen, in a catastrophe that may have its origin in a fault deep beneath Parkfield's Middle Mountain. But today, amid the sere brown hills, there is nothing to show that anything is amiss. Quietly, steadily, the fault does its work, its strains and minor quakes recorded on small, remote electronic arrays set into the ground, monitored by seismologists who are patiently waiting. PS

Texas-sized eggbeater

A 164-foot vertical-axis wind turbine planned for the Texas panhandle will be the largest eggbeater windmill yet. Its developers say that its gradated airfoil design and variable-speed operation could increase energy capture by up to 25 percent.

By NAOMI J. FREUNDLICH

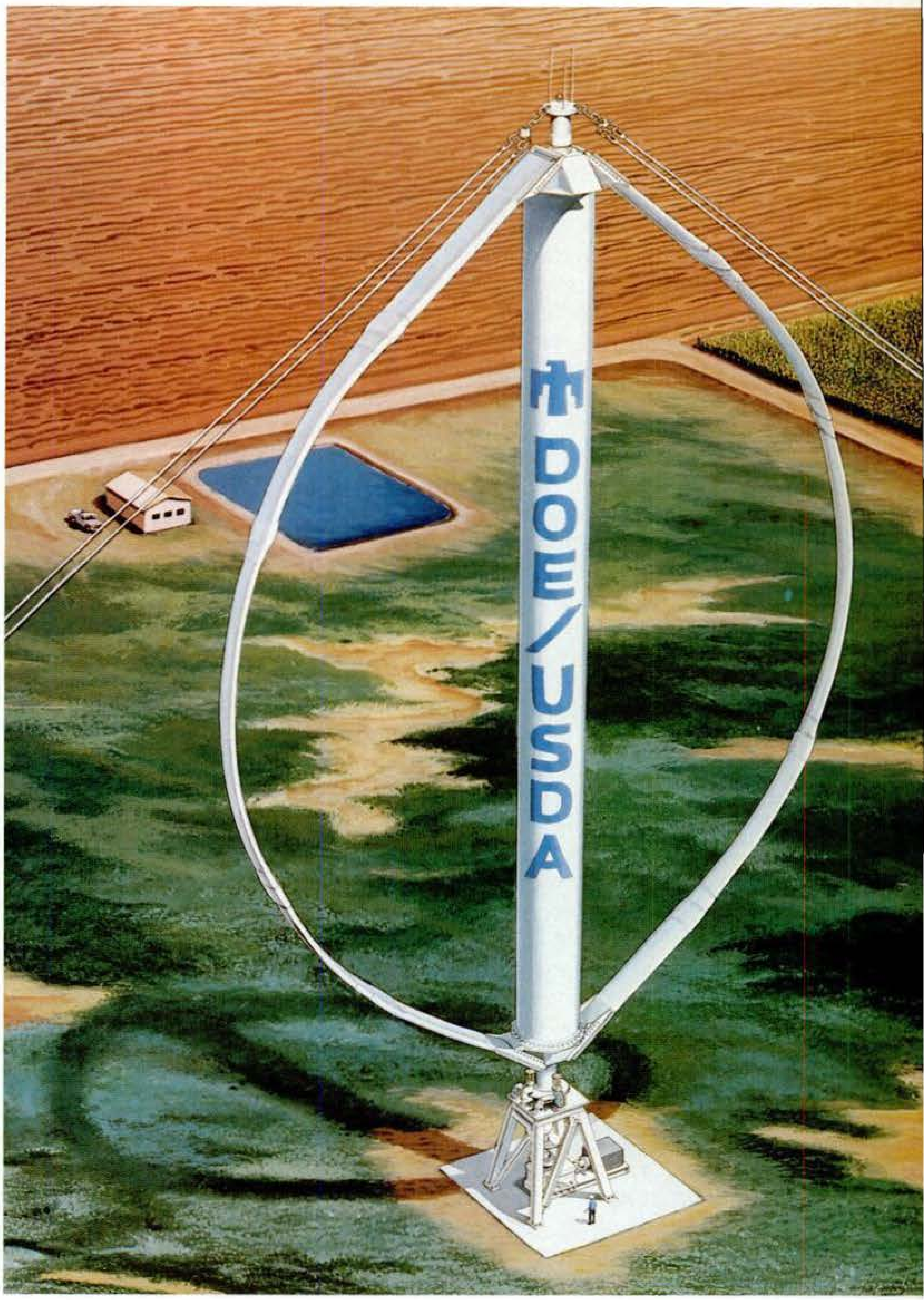
Henry Dodd is well aware that you can't fly to Europe on a wind turbine and that you can't generate electrical energy with an airplane. "Nonetheless, we use airfoils from airplanes in power-generating turbine blade design," he laments. "The airflow that occurs with wind turbines is totally different than with airplanes."

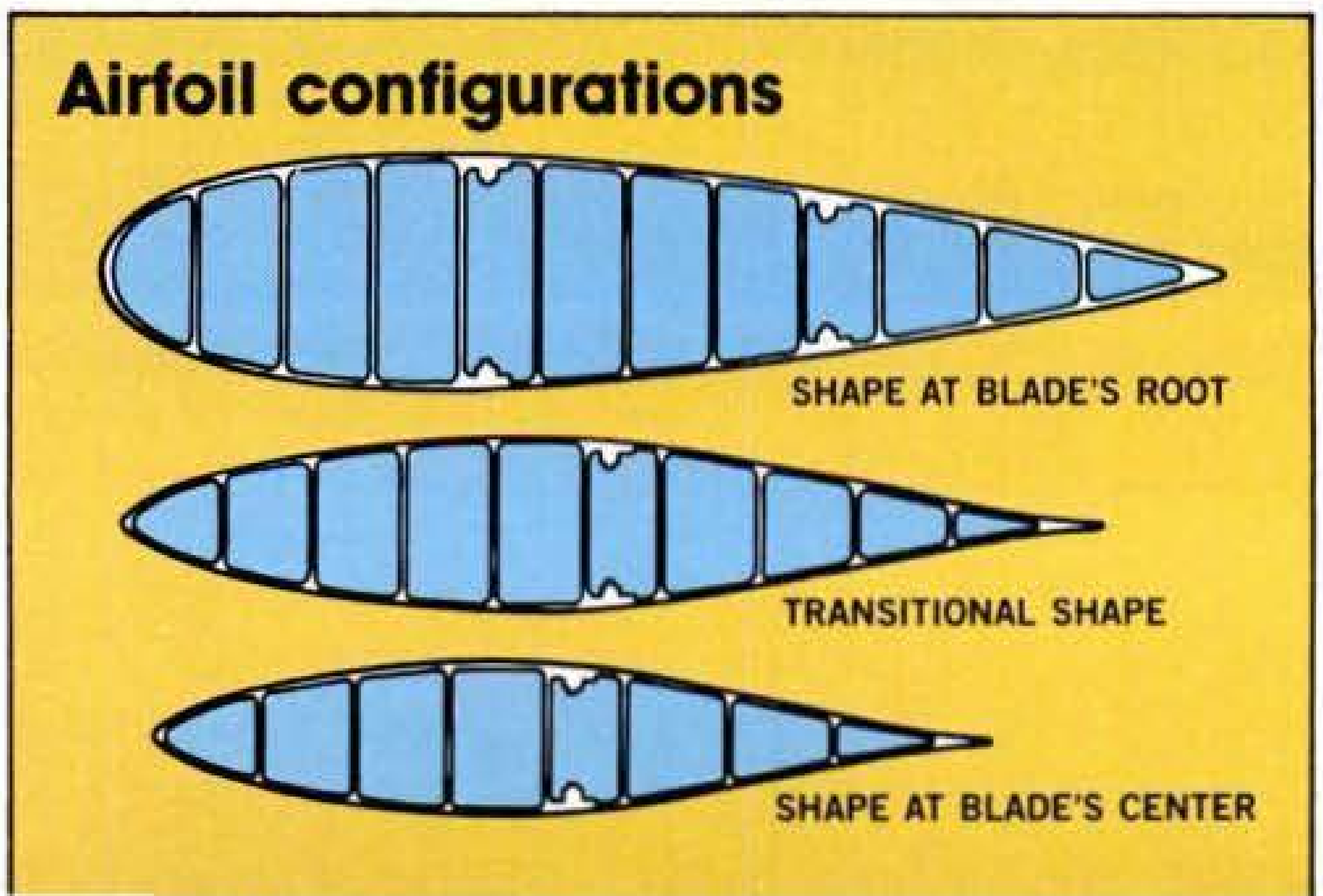
Until recently, a blade designer's main resource was a huge NASA catalog of aircraft airfoils. Now, using powerful computer modeling systems, Dodd's group at Sandia National Laboratory's wind energy research division (Albuquerque, N.M.) is designing airfoils tailored to capture maximum wind energy.

Using these new designs, Dodd's group is building the biggest vertical-axis wind turbine yet [PS, May '75]. When the 164-foot machine is erected on the high plains of the Texas panhandle this fall, the 500-kilowatt eggbeater could convert 40 to 45 percent of the incoming wind energy to electricity. Current eggbeaters have top efficiencies of 33 percent.

The new airfoils, along with computer control of blade speed, are responsible for this expected jump in effectiveness. The airfoils are narrower at the middle of the blade, where airspeeds are higher (see diagram), and a computer continually adjusts blade speed to maximize energy capture. "If you operate at a constant rotor rpm, there's only one wind speed that allows the turbine to reach its maximum efficiency," Dodd explains.

One planned test is to remove a blade to determine whether a "one-armed" windmill is feasible. This would significantly reduce the cost of a vertical-axis wind turbine. PS





Sandia's 164-ft.-high eggbeater wind turbine (above) will be built in Bushland, Texas. Extruded aluminum airfoils (right) can handle large gusts of wind, stalling in high wind to avoid excessive power generation. Airfoils narrow toward the middle of the blade for improved efficiency.

NEW **HOUSING** TECHNOLOGY

What will our homes be like in the 1990s? Today's most innovative houses suggest some trends for tomorrow.

Trend one is not new, but continues with surprising strength: Surveys repeatedly find that we want energy-efficient houses. An example: In 1985, the National Association of Home Builders (NAHB) asked 920 randomly selected homeowners what they want most in their next house. The leading choice: greater energy efficiency; 68 percent chose this. The second most popular item: less exterior maintenance (chosen by 47 percent). Obviously, we've learned to be concerned with the *total* cost of owning a home, not just the mortgage payments. You'll find that most of the houses on the following pages—"Sun Valley Supertech," the earth-sheltered "Umbrella Homes," and many in our portfolio of innovative homes—were engineered with energy efficiency as a primary goal.

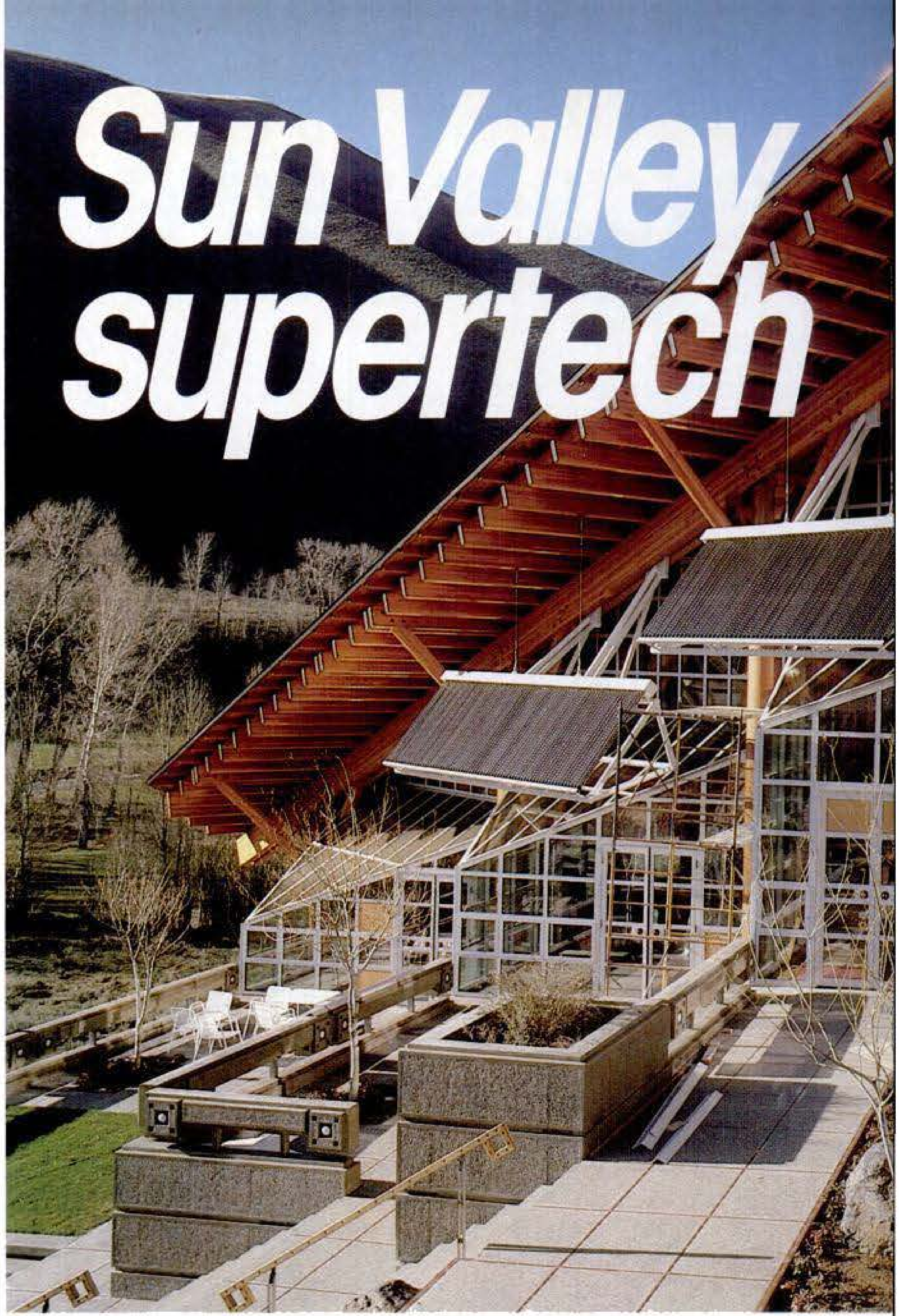
In that same NAHB survey, only 23 percent of the respondents named a bigger lot as a most-wanted amenity when they buy a new house. And a good thing, too: Finding *any* lot within commuting distance of a business center is a problem, and prices reflect the scarcity. One response to the land problem is modular housing, as designed by architect Barry Berkus and featured here in "Plug-together Modules." The modules can be configured to fit, jigsaw-puzzle-style, on practically any lot.

Another feature of today's most advanced houses is computers—as building-control and management systems. The house on our cover is practically self-tending, thanks to such a system. Some builders are putting less-capable computerized systems in more ordinary homes.

Computers, energy efficiency, modularity are but a few of the trends we discovered in our survey of new housing technology. You'll find many more on the following pages.

The Editors

Sun Valley supertech

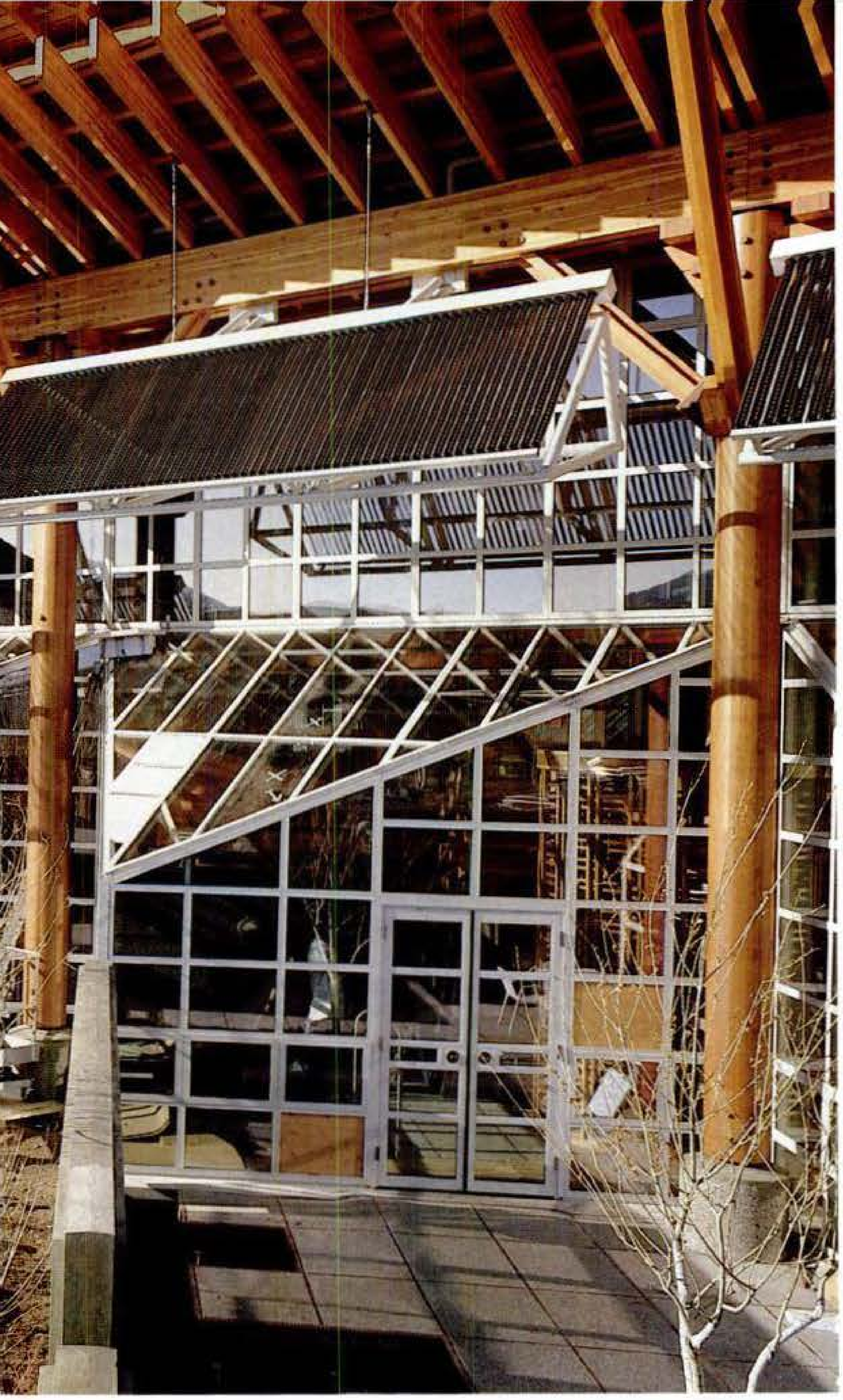


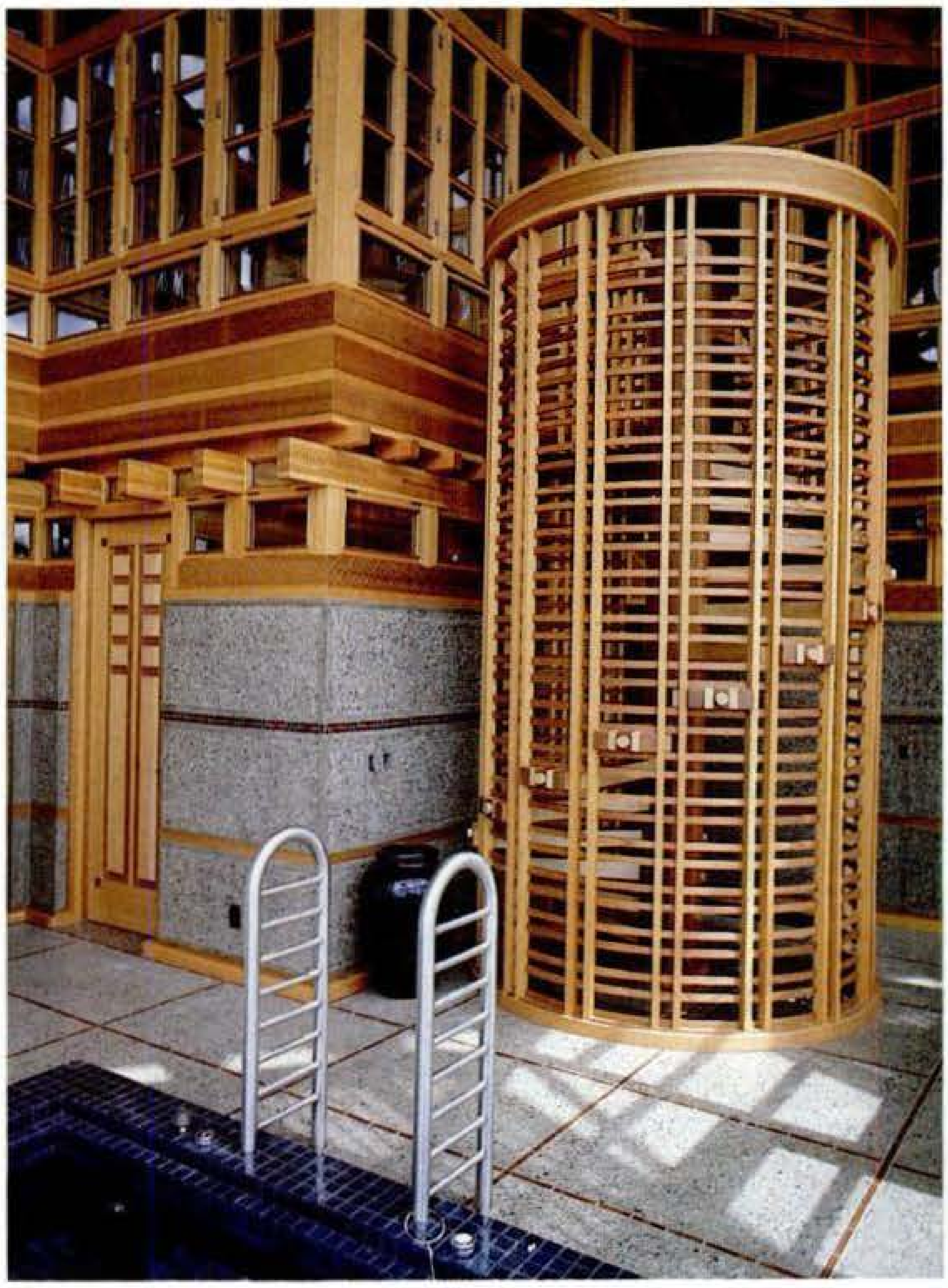
High-tech meets high-touch in a vacation house that boasts heat-pipe solar collectors, passive-solar features, evaporative cooling, and windows that may be the most efficient ever used. A computer, accessible by telephone link, is the autopilot for the house.

By V. ELAINE GILMORE
Photos by Jeff Austin

"This will be one of the most visited rooms in the home," predicts Eric Thiel, project manager for Grabher Construction, the company that built this 8,000-square-foot house in Sun Valley, Idaho. It is a remarkable statement, considering we are in the basement mechanical room and the house above is one of the most beautiful I've ever seen.

Still, Thiel has a point. Though the soul of the house is surely its striking architecture and exquisite detailing, its heart and brain are down here where a fascinating profusion of pipes, tubes, and wires converge. The house is primarily a family retreat, but secondarily it is an experiment to advance the state of the art in energy conservation and solar-heating technology. Among its features:





Heat-pipe solar collectors are suspended from sanded and oiled redwood rafters (top left). Interior detailing, including the circular staircase (top), was designed by architect Arne Bystrom. Cabinets, doors, and stairs were custom-made in small cabinet shops. Laminated redwood columns with Asian-inspired joinery (above) support the roof.

- Evacuated-tube, heat-pipe solar collectors.
- Windows that combine low-emissivity film and argon gas; some are the most energy efficient ever installed.
- Passive-solar heat retained in high-thermal-mass materials.
- A clever evaporative cooling system that employs a decorative pool and fountains.
- A computer, accessible by telephone link, that controls and monitors energy systems, alarms, and lighting.

This seamless integration of architecture and technology resulted from the collaboration of architect Arne Bystrom of Seattle, Wash., and the ENSAR Group, energy architects and mechanical engineers, of Lakewood, Colo.

The impetus—and many of the ideas—came from the owners, a couple from the San Francisco area who requested anonymity. I'll call them Mr. and Mrs. Greene for convenience. Mr. Greene, a venture capitalist by profession, is an electrical engineer by education. "In 1950 I could design a pretty good circuit using vacuum tubes and relays," he says with a grin. "There's not much market for that today." But he retains a keen interest in technology. That's the main reason Thiel predicts heavy traffic through the mechanical room.

Ted Prythero, Gregory Franta (an engineer and an architect, respectively, with ENSAR), and Bystrom began designing the Sun Valley house in 1982. Construction

Continued

started in 1983 and continued through last winter. Workers joked that they were beginning to feel like those medieval craftsmen who spent whole lifetimes building one cathedral. Indeed, the house is almost cathedral-like in the richness of its details, all designed by Bystrom.

The passive house

The east-west profile of the home's copper-clad roof mimics the slopes of the mountains behind it. Its north-south slope matches the angle of the sun at midday on the winter solstice. Around midmorning the sun begins streaming into the house (which faces somewhat west of south). Soon the temperature climbs to shirt-sleeve comfort. David Friedland, the live-in caretaker (cook and mechanical whiz) introduces me to the house.

In the sun-warmed entry he shows me the windows: conventional in appearance but not in performance. Those on the south wall have a layer of low-emissivity plastic film between two layers of glass; the spaces between are filled with argon gas. The film, Southwall Technologies' Heat Mirror, reflects radiant heat back into the sunspace ["Superwindows," PS, March]. The argon gas conducts heat less readily than does air. The windows are made by Alpen, Inc., of Boulder, Colo., and boast an impressive R-5 insulation value.

Even more impressive are the north windows in the living room and master bedroom. They have *two* layers of Heat Mirror and *three* spaces filled with argon. Result: an R-value of 6.7. Though ENSAR recommended against using large north windows, Bystrom insisted on them because of the view. The compromise: these experimental windows, specially fabricated by Alpen. "They're the most efficient ever installed as far as we know," says Friedland.

Friedland points to a fat white pipe that soars nearly to the top of the 30-foot-high sunspace, its top sliced at an angle showing a vibrant red interior. "When the temperature up there reaches eighty degrees, a fan goes on and pulls hot air through the pipe and into a rock bed below the spa/game room," he explains. Warm air from the rock bed is delivered to the room as needed.

Direct and indirect passive solar energy will provide the majority of heat for the house. Most of the remaining space heat, and heat for the spa and domestic water, will come from the active solar heating system.

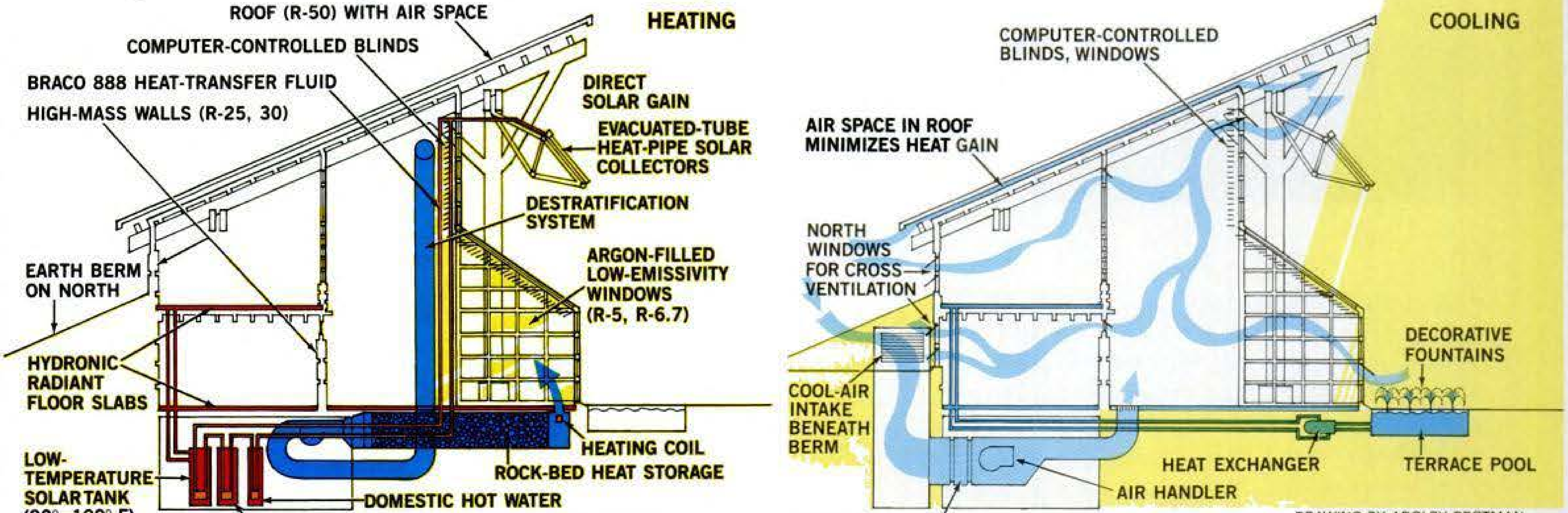
Two 500-gallon hot-water tanks dominate the mechanical room; they're bright red. A synthetic hydrocarbon called Braco 888, made by the Bray Oil Co., circulates in a closed loop between the tanks and solar collectors, thus charging the tanks with heat.

The collectors, made by Philips of the Netherlands, consist of individual glass tubes, vacuum-sealed to reduce heat transfer. "You can change them like light bulbs," notes Friedland. In the center of each is a heat pipe.

Heat pipes are very efficient heat-transfer devices because the working fluid inside (a refrigerant in this case) changes phases: When it vaporizes, it absorbs a great deal of heat, called latent heat. When the gas condenses, it releases the latent heat. In the Philips collectors the heat is transferred to the oil at the headers. The box below explains all of the passive and active systems and how they work.

A computerized building-management and control sys-

Heating and cooling the supertech way


ROOF (R-50) WITH AIR SPACE
HEATING
COMPUTER-CONTROLLED BLINDS
BRACO 888 HEAT-TRANSFER FLUID
HIGH-MASS WALLS (R-25, 30)
DIRECT SOLAR GAIN
EVACUATED-TUBE HEAT-PIPE SOLAR COLLECTORS
DESTRATIFICATION SYSTEM
ARGON-FILLED LOW-EMISSIVITY WINDOWS (R-5, R-6.7)
EARTH BERM ON NORTH
HYDRONIC RADIANT FLOOR SLABS
HEATING COIL
ROCK-BED HEAT STORAGE
LOW-TEMPERATURE SOLAR TANK (90°–120° F)
DOMESTIC HOT WATER
HIGH-TEMPERATURE SOLAR TANK (120°–160° F)
COMPUTER-CONTROLLED BLINDS, WINDOWS
COOLING
AIR SPACE IN ROOF MINIMIZES HEAT GAIN
NORTH WINDOWS FOR CROSS-VENTILATION
DECORATIVE FOUNTAINS
COOL-AIR INTAKE BENEATH BERM
HEAT EXCHANGER
TERRACE POOL
AIR HANDLER
EVAPORATIVE CHILLER

DRAWING BY ADOLPH BROTMAN

In winter, the sun enters through the south glass, and its heat is stored in concrete walls. When the temperature high in the sunspace reaches 80° F, a fan draws air from there through a decorative column and delivers it to a 500-cu.-ft. rock bed, where heat is stored until needed. A second destratification duct (not shown) delivers hot air from the top of the sunspace to an air handler for redistribution. Computer-controlled blinds track the sun to maximize solar gain. An air space in the roof keeps the copper rooftop cold to prevent ice dams; an earth berm on the north wall shields the house from winter winds.

The active solar heating system uses evacuated-tube heat-pipe collectors. These transfer heat to oil-filled headers. From there the oil circulates in a closed loop, delivering heat to a domestic-hot-water tank and to two water-filled solar tanks (one is shown in the photo at right). The high-temperature tank provides heat for the spa, small radiators, and "quick-heat" coils in the air handler and rock bed. The low-temperature tank provides heat for radiant floor slabs. All are closed-loop systems. Two small Weil-McClain VHE boilers supply backup heat.

In summer, shading and venting provide most of the cooling. High south windows, motorized and computer-controlled, open when sunspace is above 80° F. Automated blinds block the sun. Water in a terrace reflecting pool is sprayed through decorative fountains, promoting evaporative cooling. Cooled water is circulated through a heat exchanger where it cools the water that circulates through hydronic floor slabs. An evaporative forced-air cooling system serves as backup.

tem made by Andover Controls Corp. in Andover, Mass., virtually tends the house. "It monitors more than eighty parameters, including temperatures of collectors, radiant slabs, and water tanks, and the incident solar radiation," ENSAR's Prythero tells me. "It analyzes the input data and controls pumps, valves, windows, and blinds."

The computer has a built-in modem and telephone. "Using a computer and modem in his office in California, the owner can call and tell the computer he's coming in on Friday," Prythero says. "If he wants the hot tub at a hundred degrees and the window shades open, the computer will see to it."

The computer also has a vocabulary of 50 words. "If the security or fire alarm is triggered, the computer will call the proper number and explain the problem," Prythero notes. Well proven in commercial buildings, this is the system's first installation in a residence.

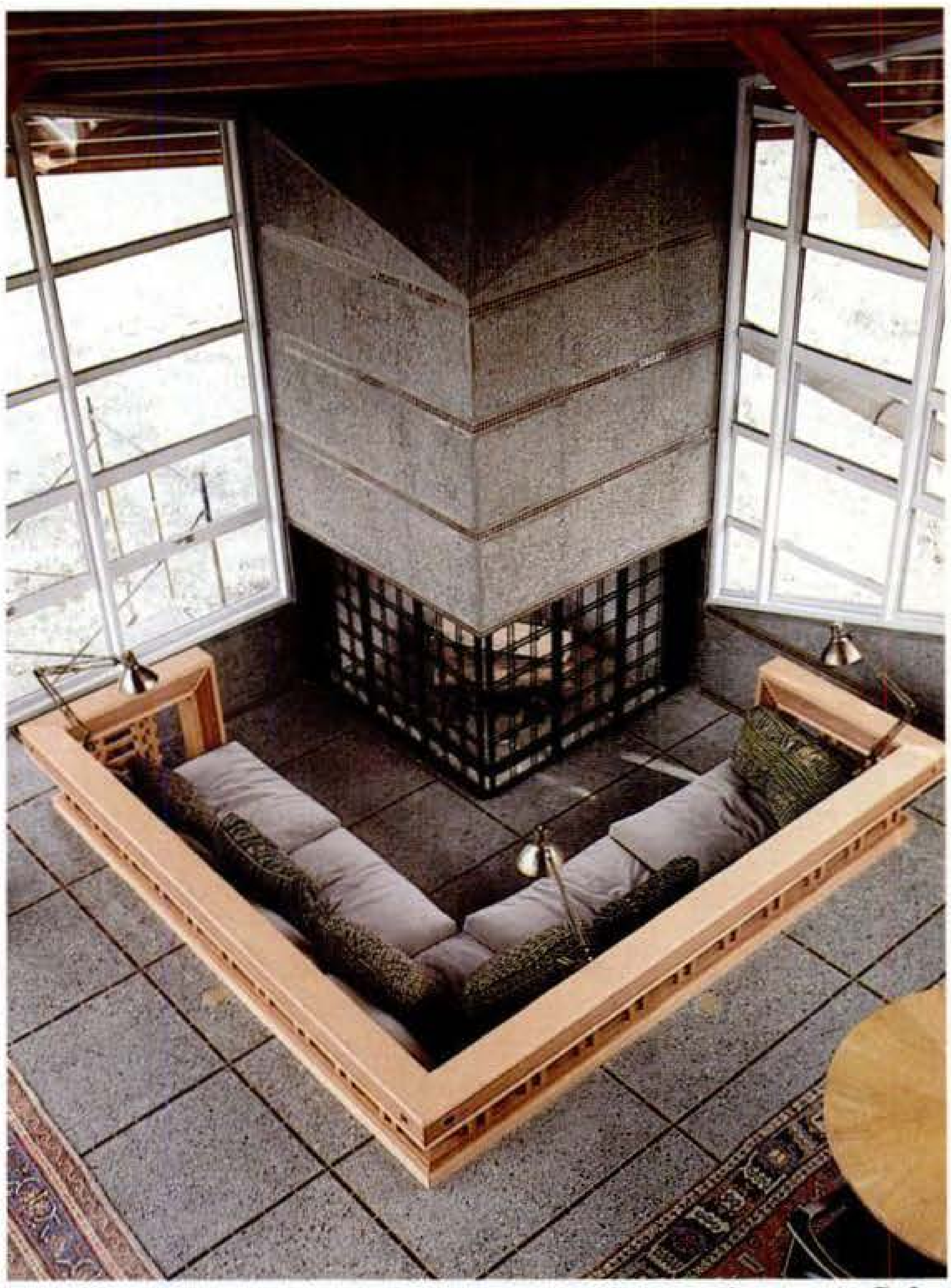
A low-voltage, programmable lighting system will be linked to the computer. "You can have lights come on at a preset time, to a preset intensity," Friedland tells me. "And you can program them to change during dinner."

Idea house

ENSAR's calculations indicate that the house will be 85 to 90 percent self-sufficient in heat and hot water. A thorough monitoring program will test that prediction.

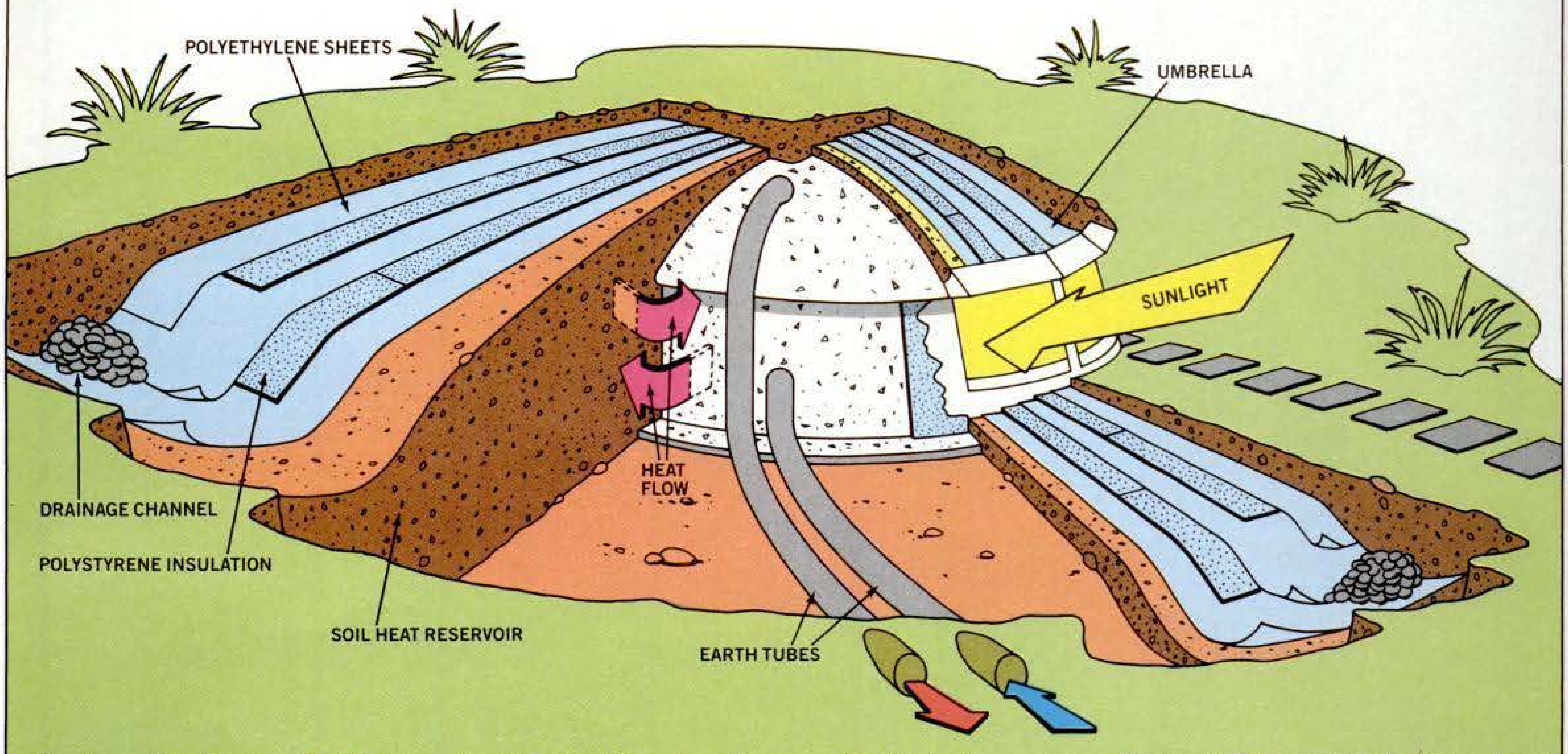
"Whatever the energy saving turns out to be, it'll never pay for the systems, even if my wife and I live to be 3,000 years old," Greene cracks with good-humored candor. "But I think some interesting ideas will come out of this that others can use in more cost-effective ways."

Despite the current abundance, Greene hasn't forgotten that oil is a nonrenewable resource. "Somebody has to do experimental work to find alternative energy sources," he says. Then quickly adds: "If we'd known what we were getting into, I'm not sure we'd have volunteered to do quite so much. But it really has been a ball." PS



Redwood kitchen cabinets feature fir inlay trim (top). Cabinets (even the door handles) were designed by architect Bystrom. Living room (above) has a sunken fireplace—and north-facing windows with an R-value of 6.7.

Passive annual heat storage



Geodome, the first umbrella home (in idealized form), maintains a 66° to 74° F temperature year-round without heating equipment in western Montana's cold climate. In summer, solar heat radiates in, falls on internal surfaces, and is absorbed into the surrounding soil. The umbrella traps heat in the dry soil until winter, when it migrates back into the house. Adding convection-driven earth tubes would modify the internal temperature by conveying outside air in.

NEW **HOUSING** TECHNOLOGY

Umbrella homes

By JOHN HAIT

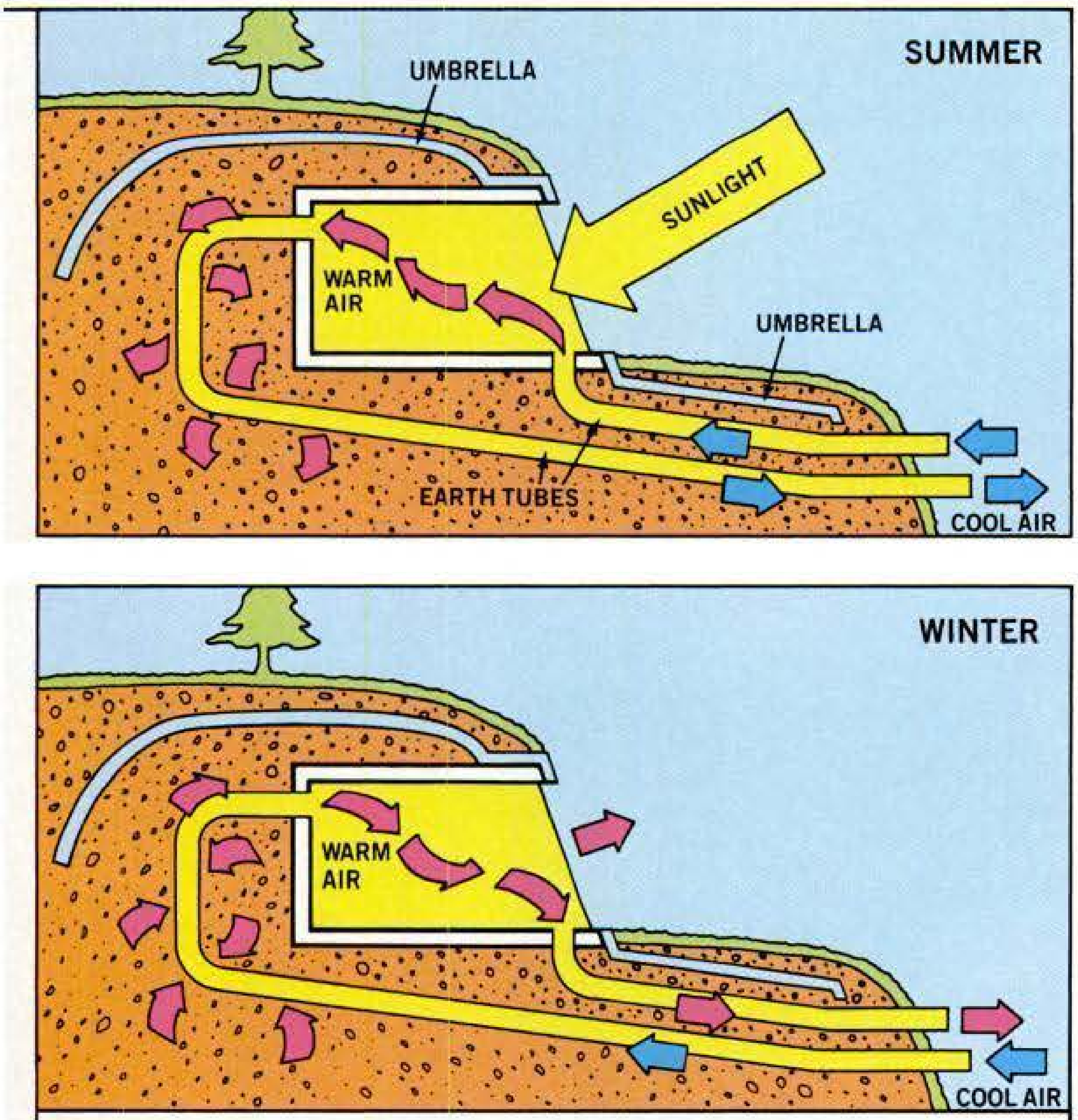
My first earth-sheltered house—an underground geodesic dome—was partially complete when the truckload of insulation my colleagues and I had ordered arrived. Right away, we knew we had a problem: How do you put flat, rigid polystyrene insulation on a round house?

We called housing experts all over the country, but no one had any ideas. Finally, Ray Sterling at the University of Minnesota's Underground Space Center suggested that we place a flat, insulating "umbrella" *in the earth above the building*. This, he said, would keep the domelike house warm by insulating the soil around it.

"What a marvelous idea!" I thought when I heard his advice. After two weeks of rigorous examination, I realized that the concept was even more promising than I'd supposed. By then I was convinced that the dry earth under an insulating/water-shedding umbrella could store enough free solar heat from the summertime to warm the house through the entire winter (see diagrams above). This meant that a house could actually be constructed with an unchanging built-in temperature, which would make heating and cooling equipment unnecessary. Now, five years later, I still think it's a marvelous idea. The Geodome, the house we built in the cold and cloudy climate of western Montana, remains at 66 to 68 degrees F, even through the coldest winters.

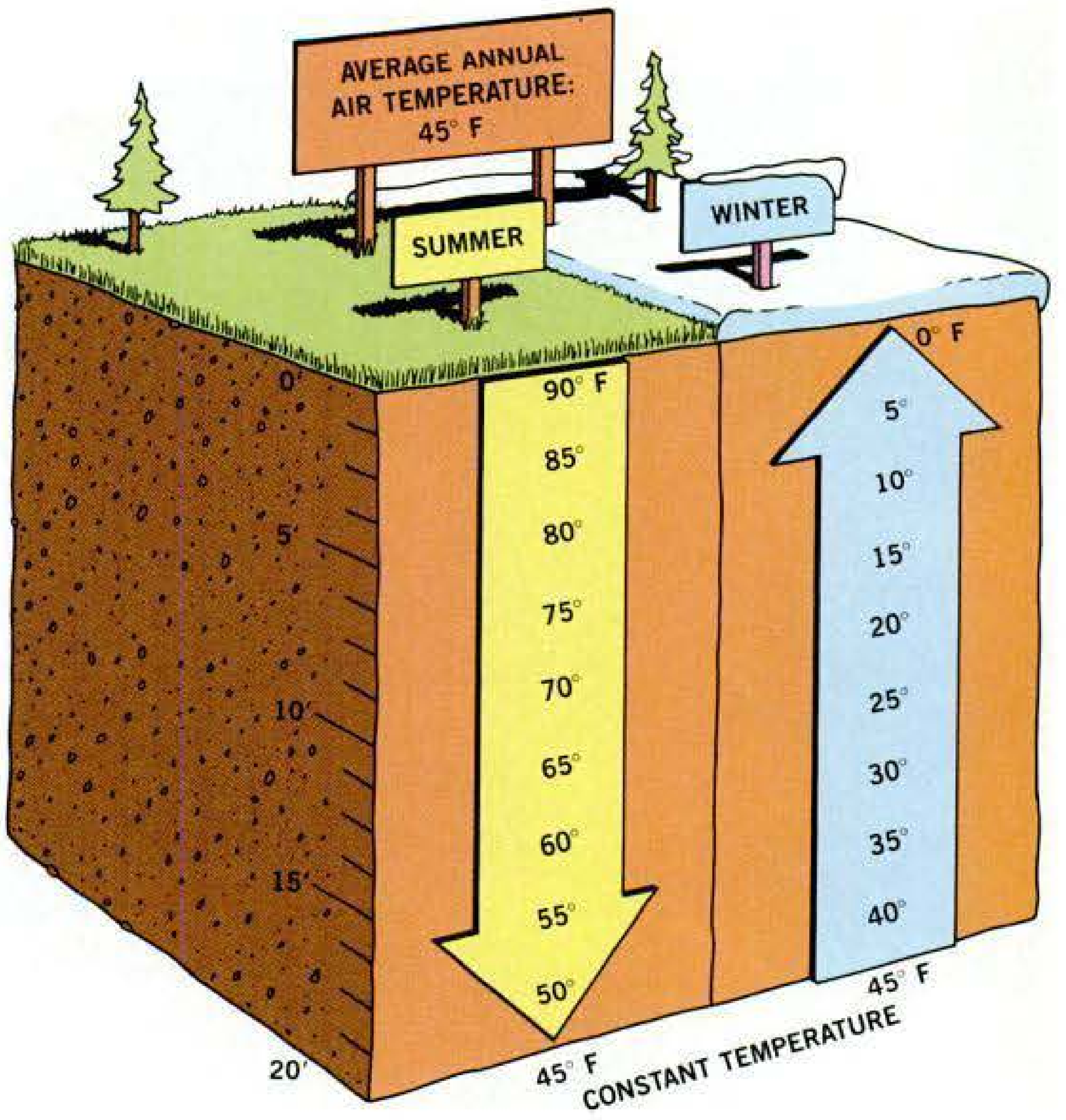
The success of the Geodome led to the establishment of the Rocky Mountain Research Center, a nonprofit organization dedicated to the development of what is now called the passive annual heat storage (PAHS) approach to free year-round passive-solar heating. Three basic points make PAHS different from techniques used in conventional solar-heated earth-sheltered houses:

- The house's window shades are *opened* to collect solar heat in summer.
- The umbrella's laminated sandwich of polystyrene insulation and polyethylene sheeting (about R-20) insulates a huge mass of surrounding dirt instead of just the house.
- The umbrella sheds water to keep the soil around the house dry.



In summer, air enters the house through an earth tube and is warmed by the sun (top); moving through the second tube, it warms the cooler soil. In winter, cool air enters, is heated by the warm earth, and passes to the house (bottom).

DRAWINGS BY MITCHELL ALBALA



Twenty ft. under the surface, the soil temperature reflects the average ambient air temperature during the year. In effect, the umbrella raises this constant temperature zone to the surface and allows the house to warm it further.

A simple underground-house design uses a novel insulating/water-shedding blanket that covers both the structure and surrounding soil. The umbrella creates a huge subterranean thermal reservoir that soaks up the sun's energy during summertime and stores it for winter heating. In many cases, the clever design makes a heating system unnecessary.

Conventional passive-solar theory tells us to exclude the abundant summer sunshine by blocking it out with large window shades because the typical (relatively small) thermal mass in a solar house can store only a night's worth of heat. Yet we're also told to make the windows large enough to capture what little solar heat we can in winter. PAHS, on the other hand, uses the summer's abundant sunshine to heat up a large body of earth around the house to a comfortable 72 degrees F or so. That warm thermal mass keeps the house and its occupants cozy all winter. Simple thermal conduction transfers heat through the walls, into the soil, and back.

Twenty feet underground, the natural soil temperature is nearly constant (see diagram above), and is equal to an average of the entire year's worth of temperature changes on the surface. The Geodome's inexpensive umbrella isolates the soil beneath it from fluctuating outdoor air temperatures above. By controlling the heat flow in and out, the blanket raises the constant soil temperature around the structure to reflect the newly established average annual air temperature inside the house. The result is a comfortable indoor temperature that varies only six or eight degrees during an entire year, while outdoor air temperatures may vary from minus 40 to more than 100 degrees F.

Although the Geodome's window area amounts to about six percent of its floor area—less than most solar homes—the summer sunshine lasts much longer, and so more solar heat is collected and stored away than is available from any passive winter thermal-collection system.

We've learned several lessons from the Geodome that have advanced our understanding of integral year-round thermal systems. First, the design temperature of 66 to 74 degrees is built in and is difficult to change. This became apparent during its first winter. The Geodome's tenant at that time, a salesman who was constantly on the road, found that the house temperature was still at 66 degrees F in March—even with a few warm bodies or appliances to add heat. We realized then that if you would like it a little warmer or a little cooler in such a house, you would have to enlarge the window area and install adjustable shades. That way, the annual solar input could

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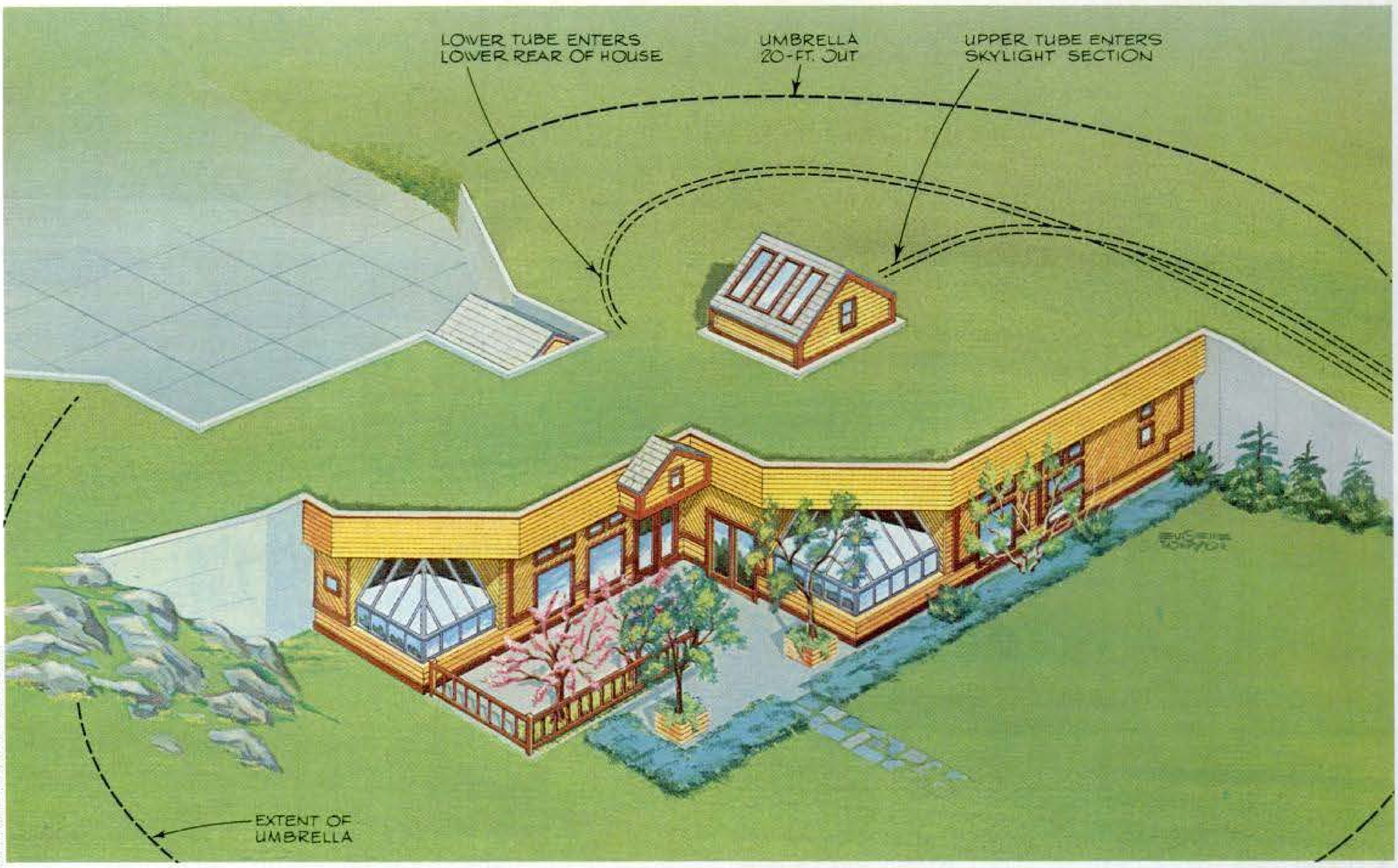

LOWER TUBE ENTERS LOWER REAR OF HOUSE
UMBRELLA 20-FT. OUT
UPPER TUBE ENTERS SKYLIGHT SECTION
EXTENT OF UMBRELLA

PAINTING BY EUGENE THOMPSON

Second-generation umbrella home in Missoula, Mont., was constructed by Tom Beaudette, the engineer of Geodome.

be altered to modify the internal temperature as desired.

Second, thermometers indicated that the umbrella altered the ground temperature much farther out from the walls than we expected. I located some National Bureau of Standards studies that showed that air-temperature changes affect the soil temperature more than 20 feet down into the earth, so we concluded that the umbrella should be extended to at least that distance beyond the walls.

Third, an examination confirmed that the earth underneath the umbrella was bone-dry, even though the soil on top was moist. The dry dirt below makes waterproofing the structure easier, while the moist soil above helps alleviate the desertlike conditions that often occur on top of many earth-sheltered houses. Note that the water table must not moisten the thermal mass.

PAHS seemed to offer a way to build energy-efficient homes that require no commercial energy supply for heating or cooling, but we realized that to become truly practical, we needed to provide for ventilation, heat retrieval, and moisture control.

No good solution presented itself until one day when I was teaching a class of students at the center about convective heat flow. After a time, the discussion turned toward the use of earth tubes—pipes in the ground that bring in outside air for ventilation. Then one of the students asked about convective heat flow in earth tubes. Before I knew it, the solution to our problem was sketched on the chalkboard: an open-loop, convection-driven earth-tube system (see diagram on previous page) that draws outdoor air into the house to be heated by the summer sun, transfers it to the buried earth tubes where it passes some of its warmth to the relatively cool soil, and finally exhausts it outside. In winter, the cycle would reverse itself.

Essentially, the earth tubes act as heat exchangers: If the air in the tubes is warmer than the earth, the earth soaks up and stores the heat. If the soil is warmer than the air, it gives up heat to the air flowing through the tubes (see diagram). In this way, the temperature of the outside air can be altered to provide the house with warm fresh air in winter and cool fresh air in summer.

The tubes themselves must be very long (between 150 and 200 feet) so they can snake their way back and forth through the soil under the umbrella. (For clarity, the tubes in the diagrams are shown straight rather than bent.) Typically, we use earth tubes that are between four and eight inches in diameter. We lay each pair out under the umbrella so that they slant downhill from the house to permit water runoff and so they both exit the ground at the same elevation.

This type of earth-tube arrangement differs considerably from the earlier "cool-tube" installations, which have been in use for some time. A single cool tube allows air to flow only one way—into the house. The house can inhale, but it cannot exhale. To exhaust stale air in winter, a window or vent must be opened, which would dump large quantities of heat outside. Also, lacking the insulating/water-shedding umbrella, cool tubes do not have the warm earth environment that allows the air in the tubes to be heated as well as cooled. Properly coupled, the open-loop, convective-heat-flow earth-tube system and the PAHS system can provide free, year-round heating, cooling, and ventilation for the earth-sheltered home.

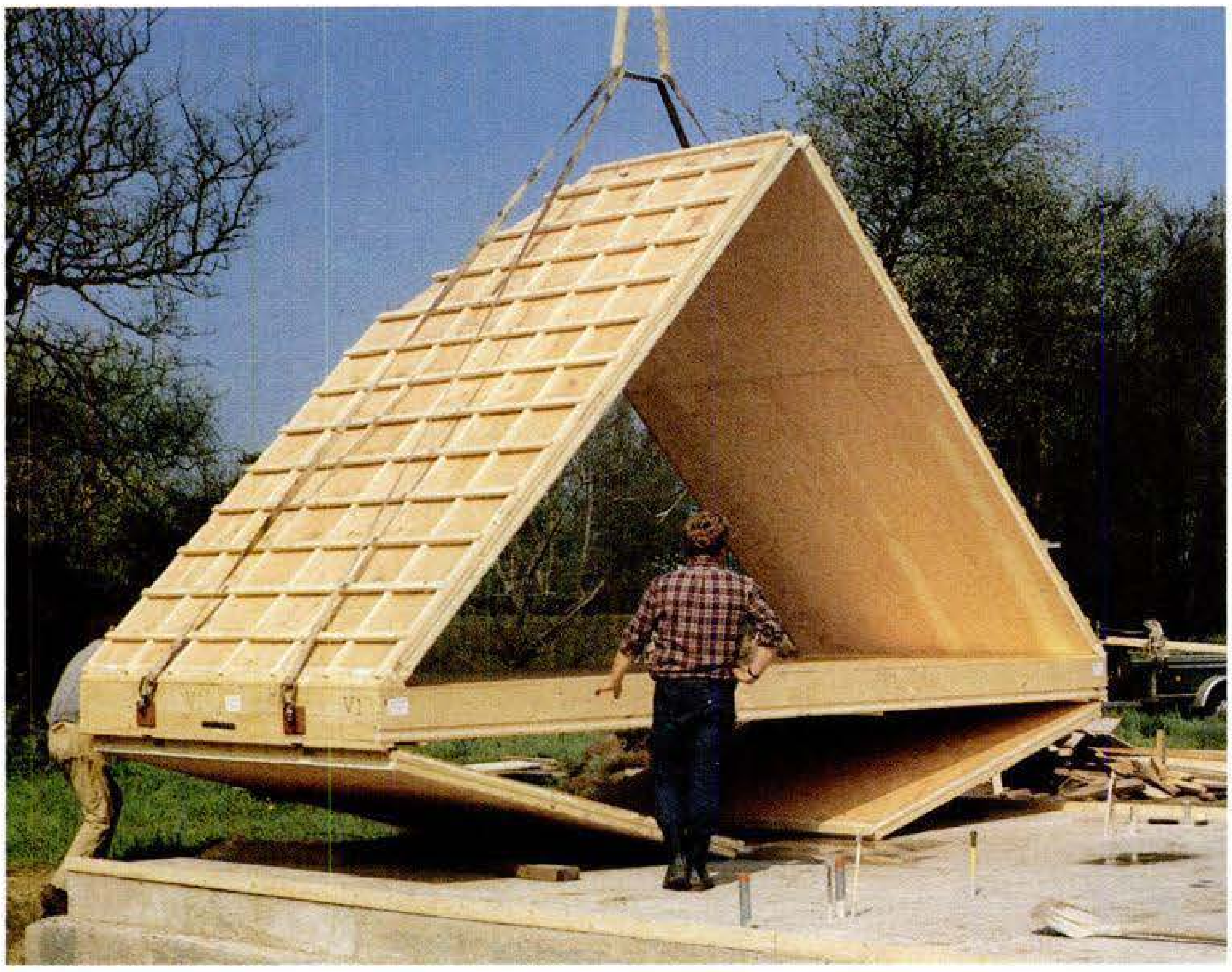
This still-experimental housing technology is already being used to satisfy at least a portion of the heating needs for several recently constructed earth-sheltered homes. It is also being built into a number of full-fledged PAHS earth shelters, such as the house depicted above, which was constructed by Tom Beaudette, the engineer of the Geodome.

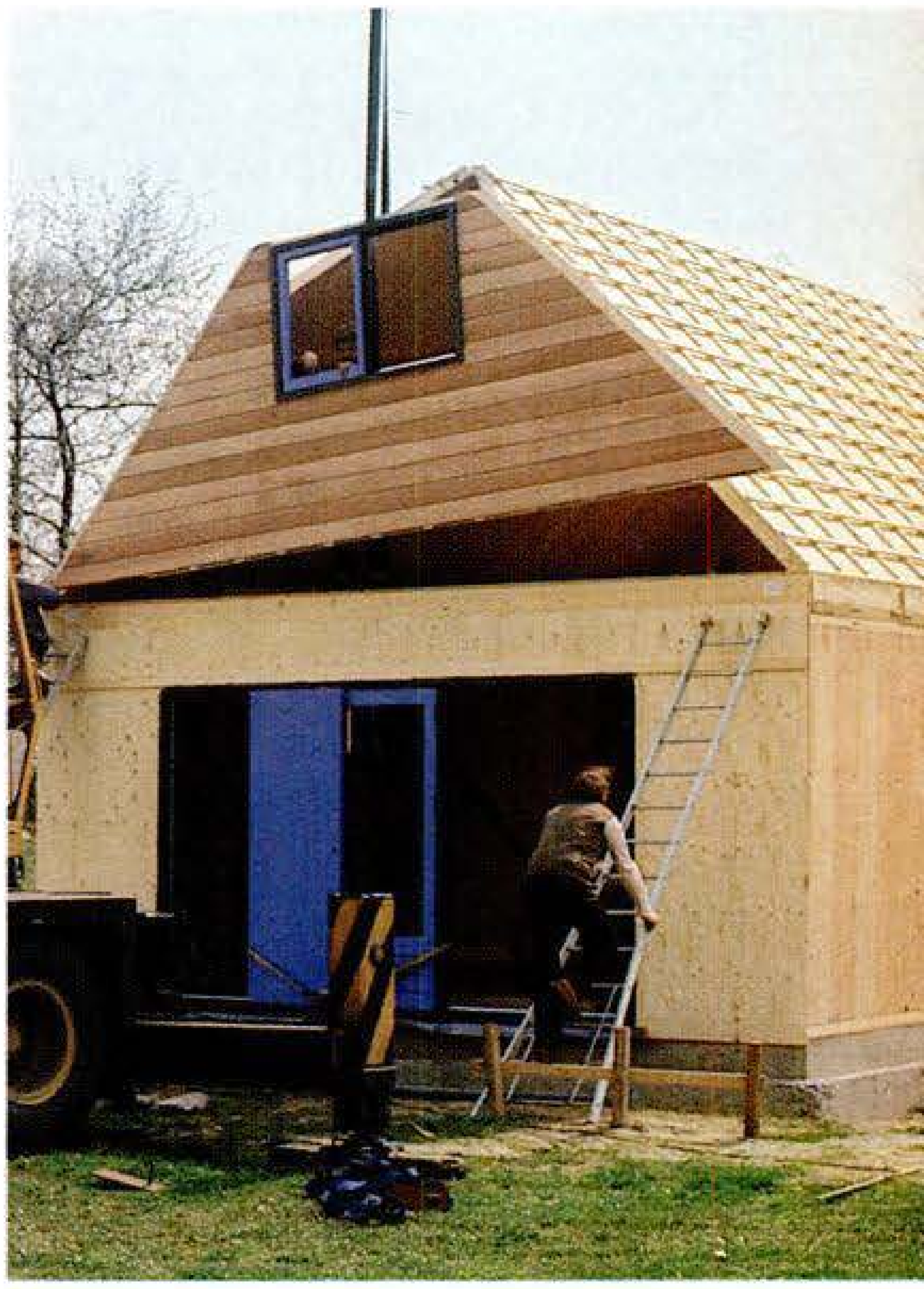
Detailed explanations of these concepts are provided in my 152-page book: *Passive Annual Heat Storage, Improving the Design of Earth Shelters.* It's available through your local bookstore or, postpaid, directly from the Rocky Mountain Research Center (Box 4694, Missoula, Mont. 59806) for $14.95. PS

Innovative homes: a portfolio

High labor costs have inspired builders to find faster ways to put up houses. Here are four surprising systems—in wood, concrete, and fiberglass. And in Phoenix, a community gets electricity from the sun.

PULL CABLE **A,** LOCK HINGES **B,** MOVE IN

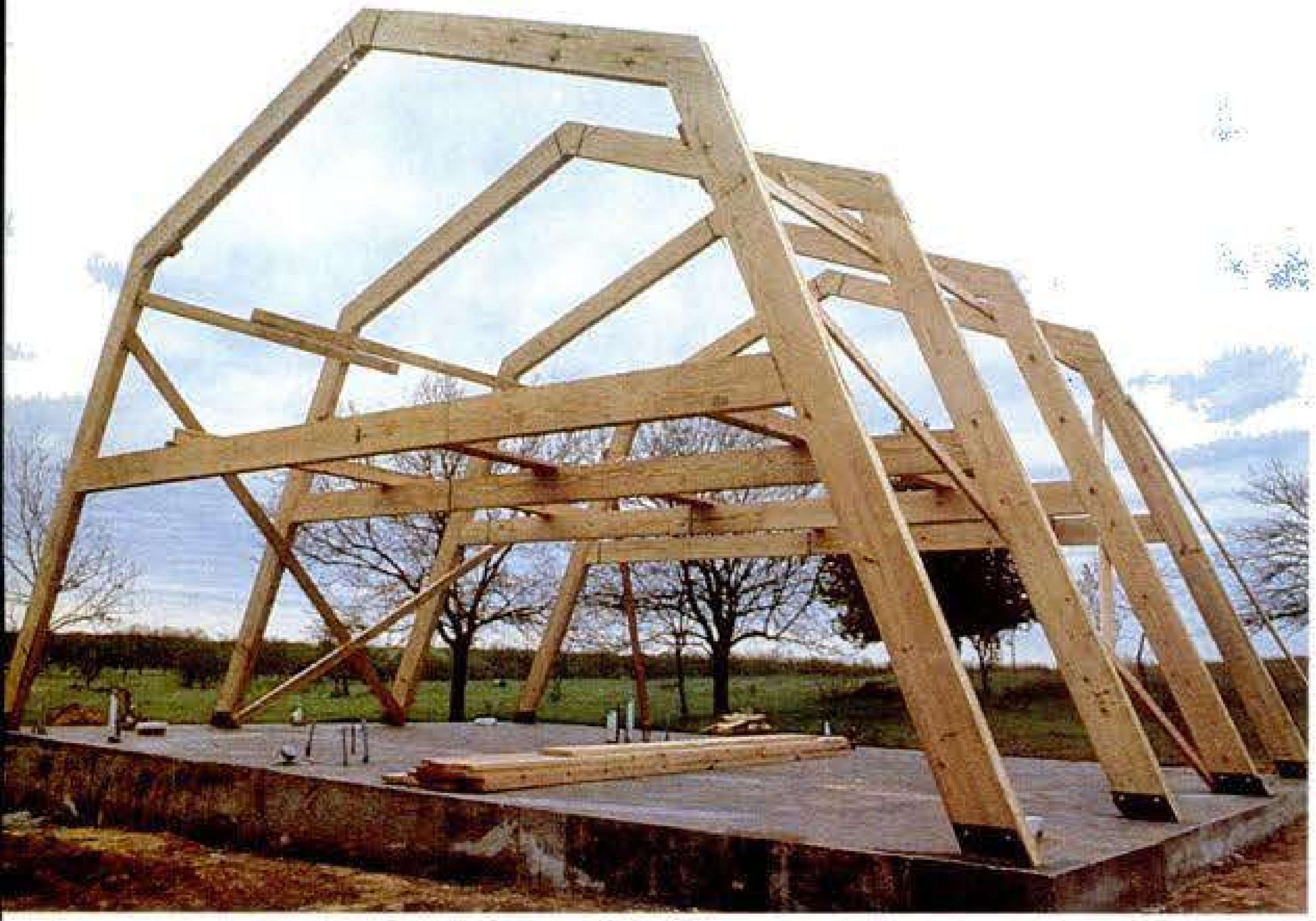




First there was the incredible shrinking man. Now meet the incredible expanding house. Designers from a Dutch company called Folding Engineering (Scheepmakershaven 69, 3011 VE Rotterdam, The Netherlands) have developed an entire house shell, minus the front and back facades, that folds up accordion-style into an eight-by-eight-by-20-foot packet. A paradigm of portability, this packet can be delivered by truck to your building site, unfolded, and set on a prepared foundation in less than a half-hour.

At the chosen site, the roof section is unfolded first. Then a mobile crane hooks onto either side of the packet (see photo). As the crane begins lifting, the hinge-connected side walls unfold and are locked and fixed to the floor below. After expansion, an extra layer of plywood or fiber-cement board is applied on top of the floor for added strength. Shown above is the basic one-story Foldex model, but these foldable homes can have up to three hinged levels in a single packet. The units can be creatively arranged to form condominium complexes or large private homes.

Mass-produced stressed skin panels, about four by 16 feet, are the structural units of the houses. The panels have an internal frame of wooden ribs covered on both sides with plywood or fiber-cement board, and are filled with three inches of insulation. The expandable house can be tailored to different climates by changing the amount of insulation. Finishing touches, such as brickwork, paneling, extra windows, or a barnlike roof variation (see photo), personalize the end product. A one-story 93-square-foot house shell, including delivery to a U.S. site, is about $9,600. The mobile crane charge is extra.—*Naomi J. Freundlich*



FAST FRAME-UP AND ENERGY EFFICIENCY, TOO

The shells of Don-Tech Building System's modified A-frame structures go up in three or four days, reducing total labor costs by 25 to 30 percent, claims the company. The quickie buildings—used as homes, cabins, even a church—start with six-inch-wide laminated-wood trusses that form the framework for both the walls and roof.

Don Wiley, owner of Don-Tech (6001 N.W. 120th Ct., Oklahoma City, Okla. 73132), got the idea for his patented home design while building barn-shaped storage sheds. He found that shed trusses with a 67½-degree slope were the strongest. "I used to be a geometry teacher, and I know it works . . . but I really don't know why," he says.

The walls are made of six-inch-thick expanded polystyrene foam, laminated with waferboard siding. Their R-30 insulation value can mean a 50-percent drop in utility costs, Wiley claims. The homes cost $35 to $40 a square foot. *—Dawn Stover*

SUN-POWERED SUBDIVISION

In Phoenix, where daytime summer temperatures can remain above 100 degrees F for weeks and electricity bills climb as high as $350 a month, residents of Solar One have all the free power they need. In fact, they expect to get small monthly checks from a nearby utility, the Salt River Project, for the extra electricity produced by a photovoltaic cell "farm" adjacent to their 24-house community.

The cells convert sunlight into electricity and feed it into the local utility grid. During peak hours, from noon to sundown, the subdivision's homeowners sell energy to the utility. After sundown and when the sky is overcast, they buy power from the Salt River Project. If residents do their baking and laundry in the morning and turn off their air conditioners in the afternoon, they should turn a profit.

To keep residents cool during the afternoon hours, John F. Long, Solar One's developer, used old-fashioned construction to complement the modern power supply. Workers made the 21-inch-thick adobe-like walls of the houses by packing a mixture of rammed earth and cement between forms using pneumatic hammers. The walls are insulated on the *outside* with two-inch foam board and reflective foil. The houses, ranging in size from 1,600 to 2,200 square feet, cost from $78,000 to $150,000. The price does not include the micro-utility; it was financed with tax credits and will be sold to the homeowners' association for a nominal sum after five years.

Solar One's name hints at Long's future plans. He says he intends to construct a solar town with 30,000 homes when the cost of photovoltaics drops.*—D. S.*

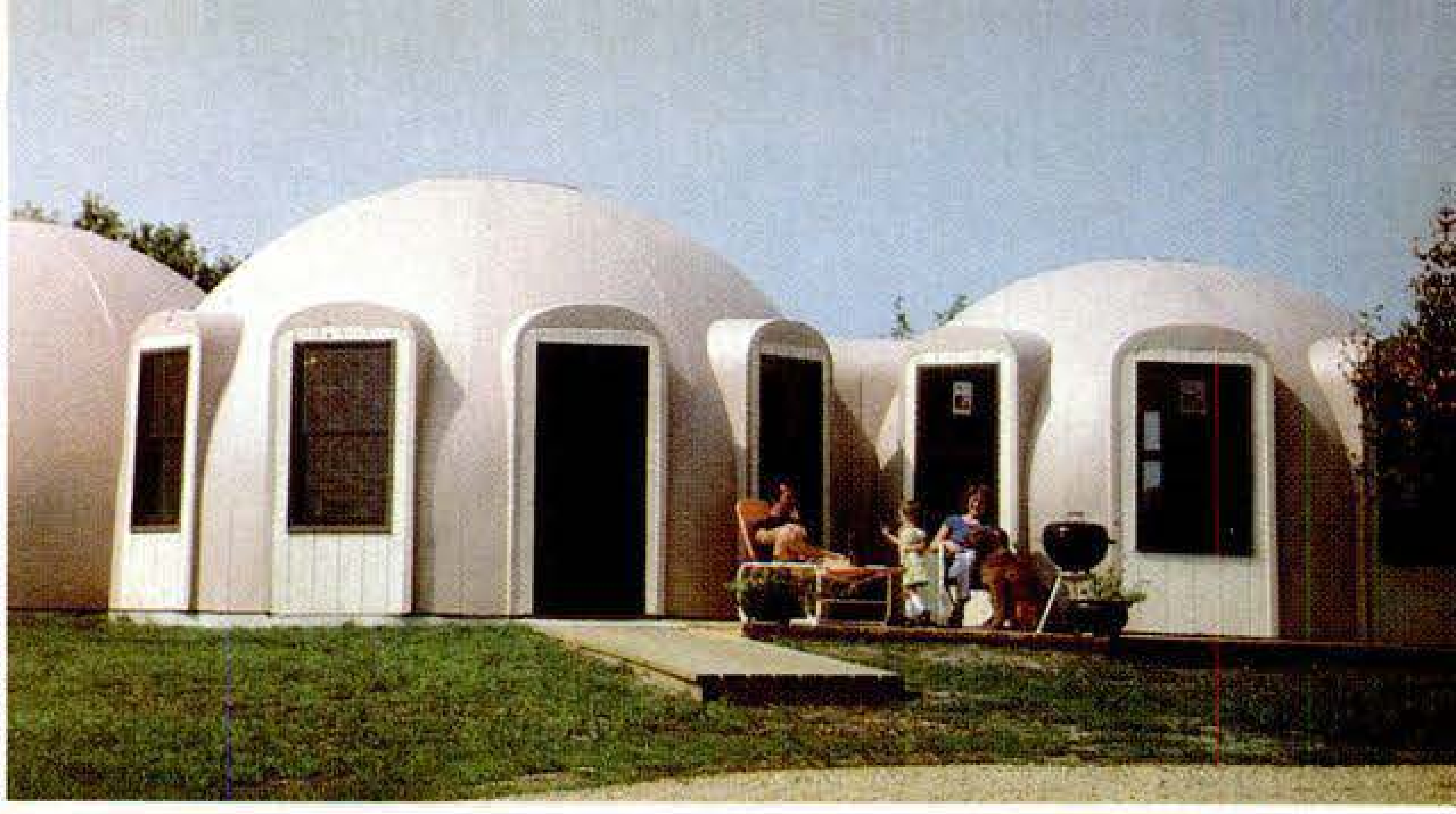
ONE-HOUR DOME HOME

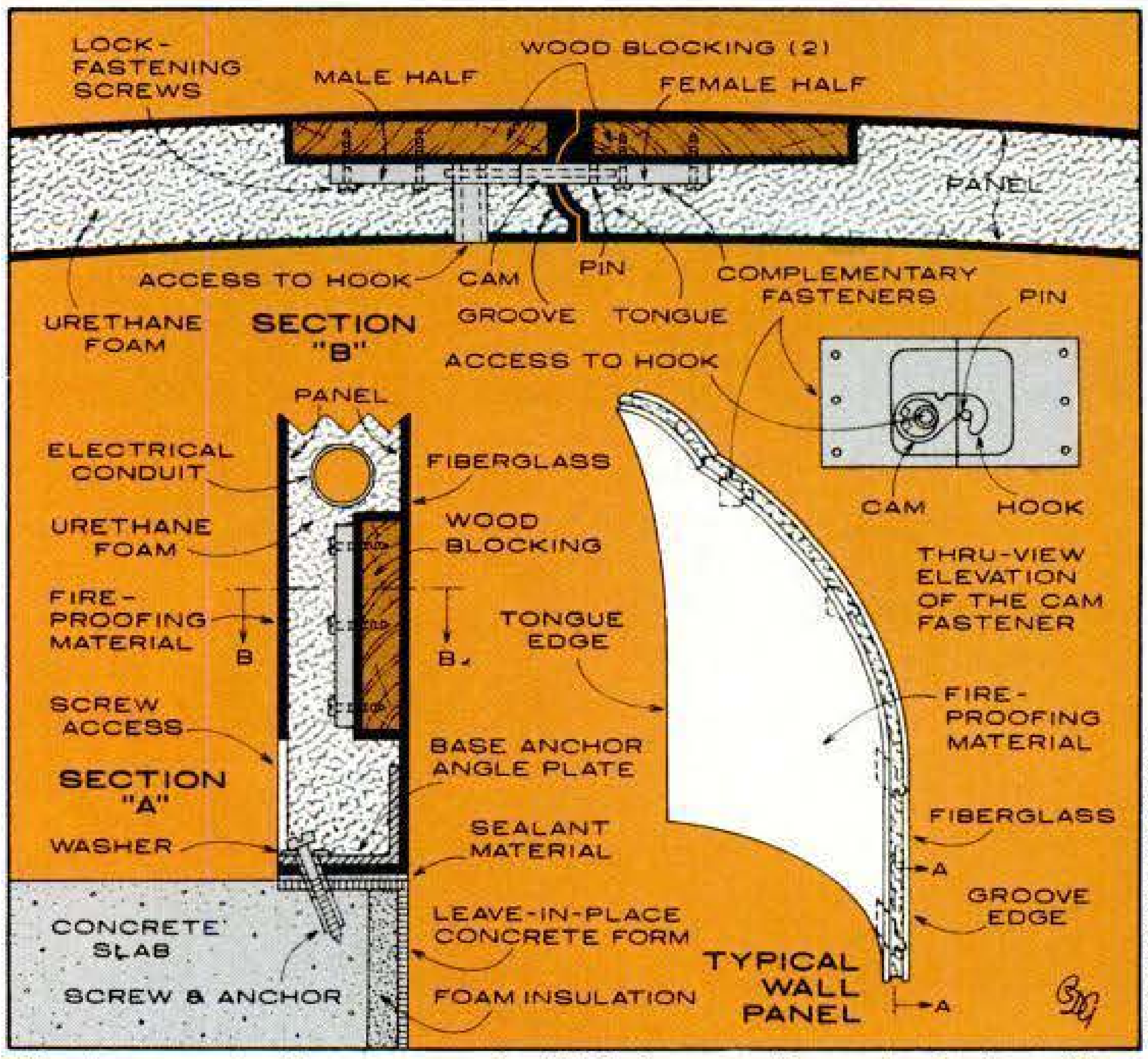
The fiberglass shells of these affordable domes are similar to fiberglass boat hulls. Indeed, the domes can be towed behind more streamlined watercraft to remote waterside sites. Called Xanadomes, they stand alone or in clusters. It is easy to add or dismantle a spare dome. "When your children are old enough to leave, you just tell them to take their room with them," says Norman Ritland, who designed the domes. "That's the start of their new house. It's the only system you can build room by room, as you need it," adds Ritland, who heads Custafoam, the parent company of Xanadome Structures (Box 311, Rte. 4, Mauston, Wis. 53948).

The parts are standardized and interchangeable, and each builder creates his own design. Made of portable sections that fit together like orange slices, the domes resemble igloos and hogans—homes once used by Indians who lived in the area where Xanadome is located. The resin-impregnated fiberglass exterior, similar to a car body, can be customized in the same colors used for Corvettes—or painted with a flat latex. The shell is insulated with polyurethane foam, and the interior is finished with Zonolite—a fireproof mixture of vermiculite and portland cement. A cap or skylight fills in the hole at the top of the dome (see drawing).

Individual domes—available in 10-, 16-, and 20-foot diameters—can be connected to each other by joining protruding gable sections. Mix-and-match panels come with windows, doors, alcoves, or windowless vertical walls for hanging pictures or installing cabinets. The base price for a 20-footer is $4,700, but a finished dome, including delivery, assembly, and a concrete foundation, costs around $6,500. Conduits and electrical outlet boxes are molded into the walls and included in the price. Planning kits are available from Xanadome for $8.50.

Xanadomes, with an R-25 insulation value, are suitable for any climate. A few will be flown to upper Alaska. Others will be used for government housing projects in Belize and Jamaica. Xanadomes are low-cost options for principal residences, cabins, or rooms added to conventional structures. *—Bill Hibbard*

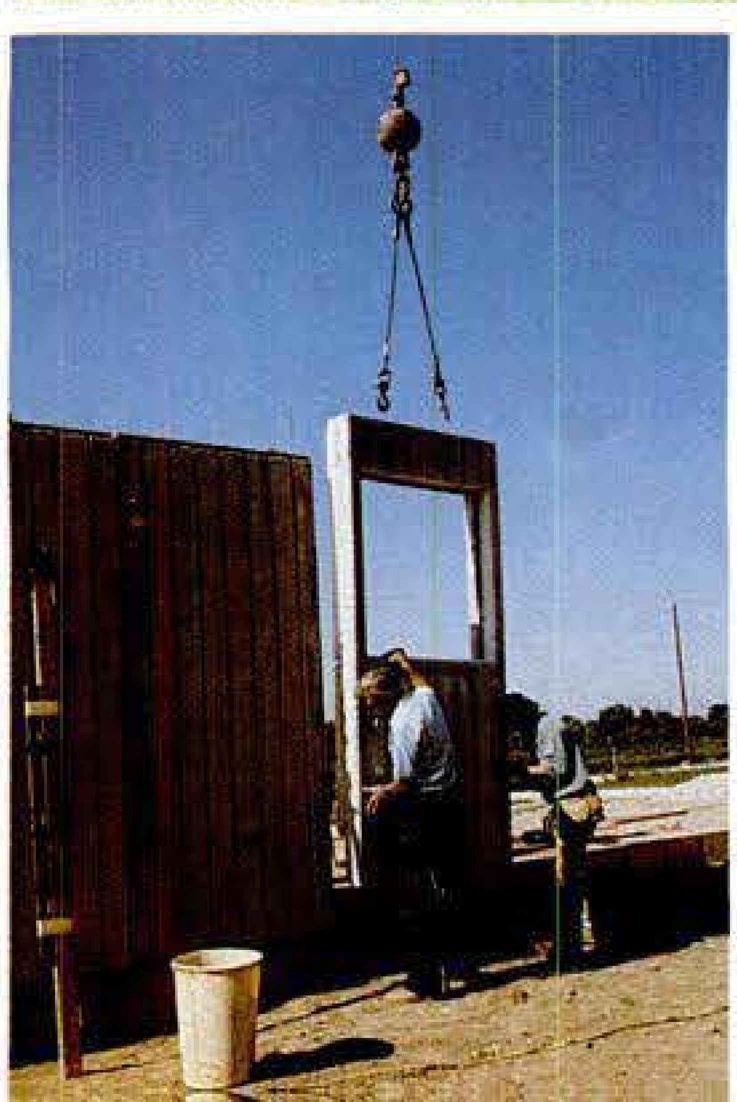


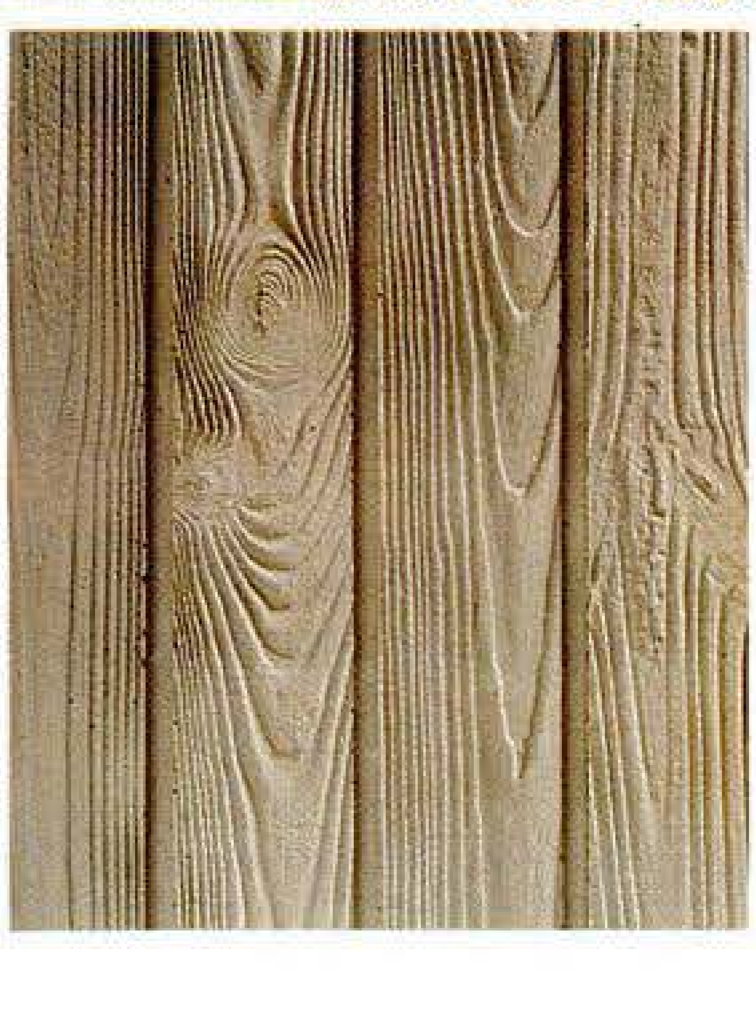


DRAWING BY CARL DE GROOTE

The tongue and groove of adjoining sections lock together with a fitting embedded in the foam insulation. A cap or skylight crowns the dome, which is bolted to a foundation. Four workers can assemble a dome in an hour, sealing the exterior joints and spraying the interior with fireproofing material. Only one tool and a stepladder are needed.

WOOD-LOOKING WALLS (psst—THEY'RE CONCRETE)





More than 80 homeowners in the Indianapolis area are having it both ways: the appearance of a wood house coupled with the strength and fire resistance of concrete. Their houses have Walston Walls—named after designer Everett Walston—made of concrete panels precast in wood-textured molds. The 700-pound Walston walls consist of one-inch-thick fiber-reinforced concrete supported by steel-reinforced ribs, seven inches of polystyrene insulation inside the concrete, and furring strips for drywall installation. Some have precut and framed openings for doors or windows. They are manufactured in four-foot increments by Beaver Products (16101 River Ave., Noblesville, Ind. 46060).

One flatbed trailer delivers the whole house, and it takes only five or six hours to erect the walls. The panels are lifted with a crane by loops of cable embedded in the concrete, and braced until roof trusses are installed. Builders put an insulating rope between the panels to permit expansion and contraction, caulking the outside with urethane rubber to make the house airtight.

Walston Walls can be painted with latex, stained, or left natural. The concrete panels are sound deadening and provide thermal mass to reduce heating and cooling expenses. Their insulation rating is R-35, about 24 points higher than that of a conventional frame house with 2 × 4 stud walls. A finished Walston Wall house costs between $34 and $40 per square foot.*—D. S.*

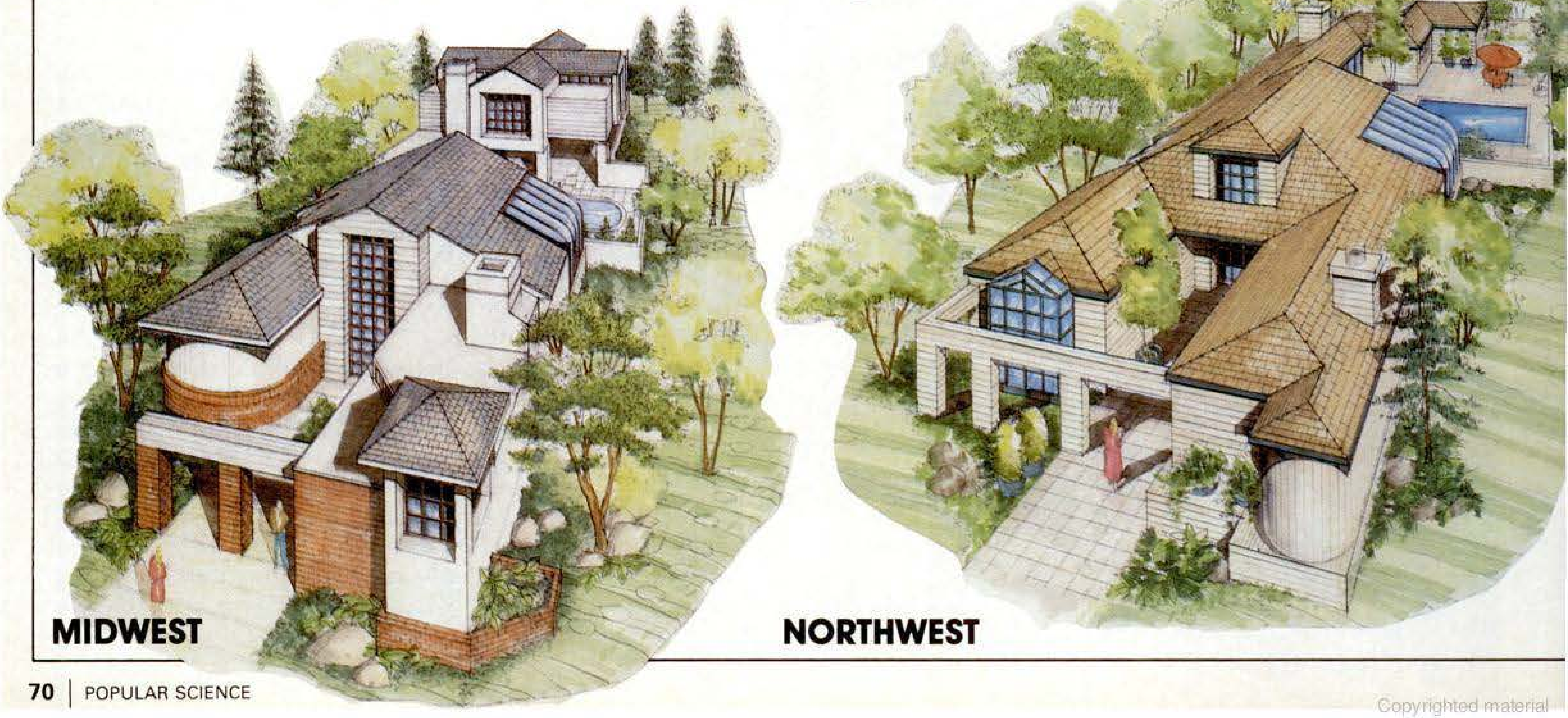
NEW **HOUSING** TECHNOLOGY

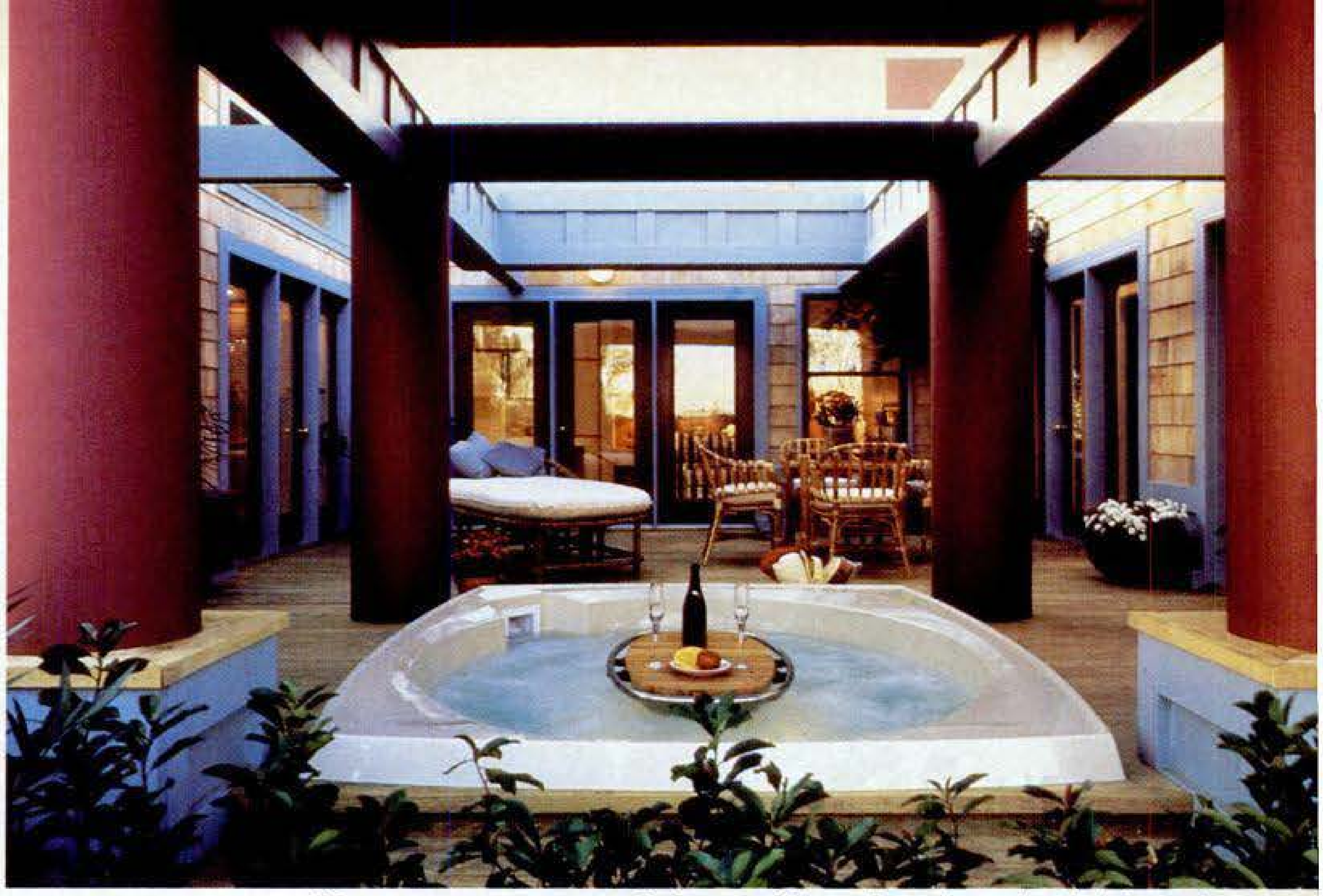
Plug-together modules

let you design your dream house

Unveiled at the National Home Builders Show in Dallas, this project points the way for manufactured housing. Three or four modules splice together for a variety of floor plans.

Choose an exterior and roof line for your region





House wraps around three sides of atrium deck (above), with spa tucked under temple-like canopy (seen in full in photo at far left). Built-in greenhouses on both sides of home also bring outdoors inside. Entry deck (center) shows off contrasting sidings: stucco-like Dryvit on the cylindrical ends of each wing and walls of natural red cedar shingles.

By AL LEES
Photos by Robb Miller

"They told me this was a *modular* house—one that rolls over the highway like a mobile home," the woman ahead of me in line protested as we inched closer to the most popular exhibit in Dallas's vast convention center. "It just can't be," she decided as we drew nearer the handsome, sprawling structure. Our line had snaked past many other lavish displays at this annual builders' show and now brought us to the only complete house assembled within the hall.

As we stepped up onto the front deck between two cylindrical stucco ends of the flanking wings, and on into the open-plan living-dining area, I could appreciate my fellow pilgrim's skepticism. It was easily the most elegant and spacious manufactured home I'd seen. But I didn't share her surprise. Architect Barry Berkus has dubbed this display house NEST '86 to distinguish it from a similar modular he unveiled at last year's builders' show in the Houston Astrodome. He'd labeled that one NEST—New Expanding Shelter Technology. I reported on it in

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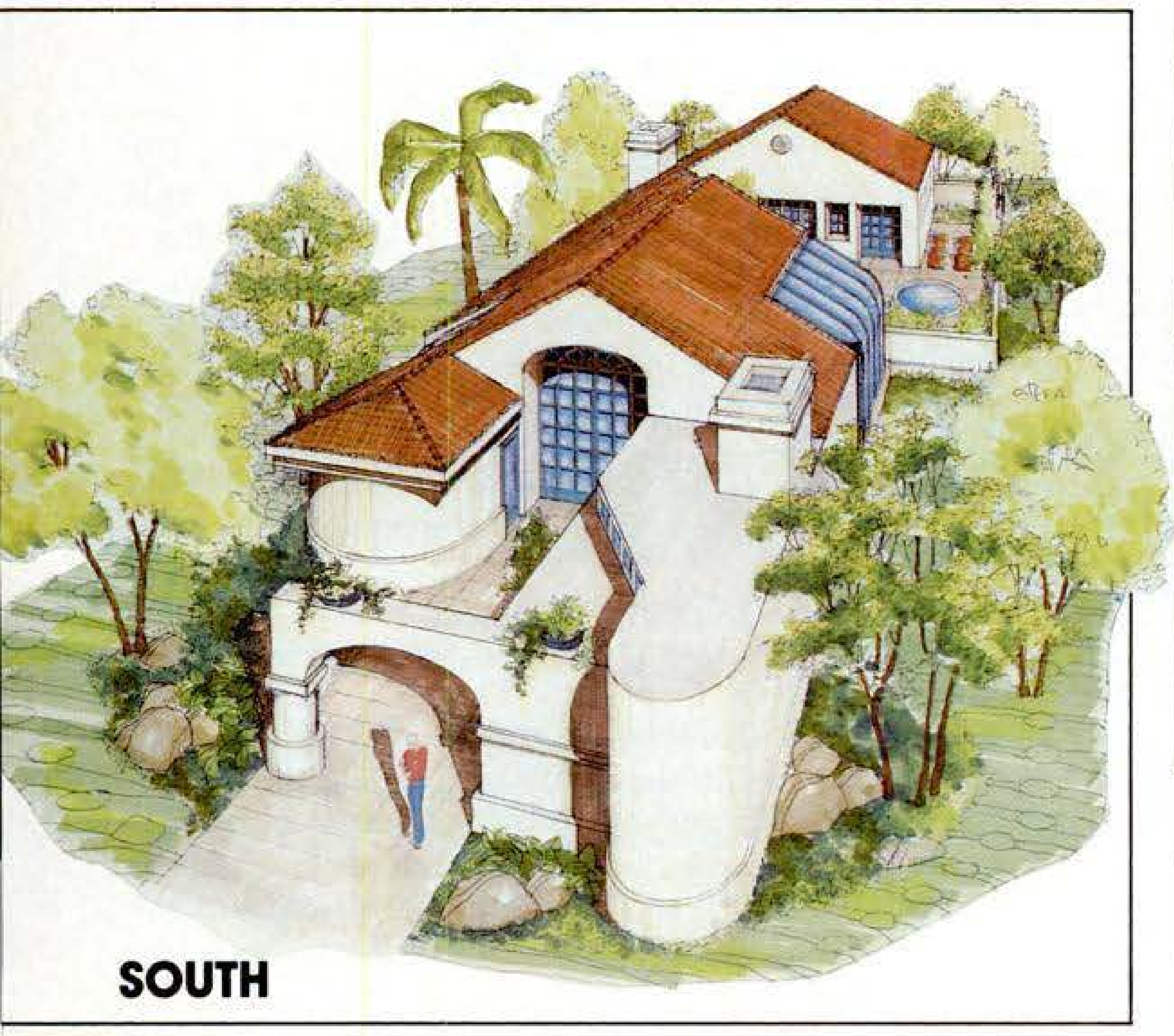
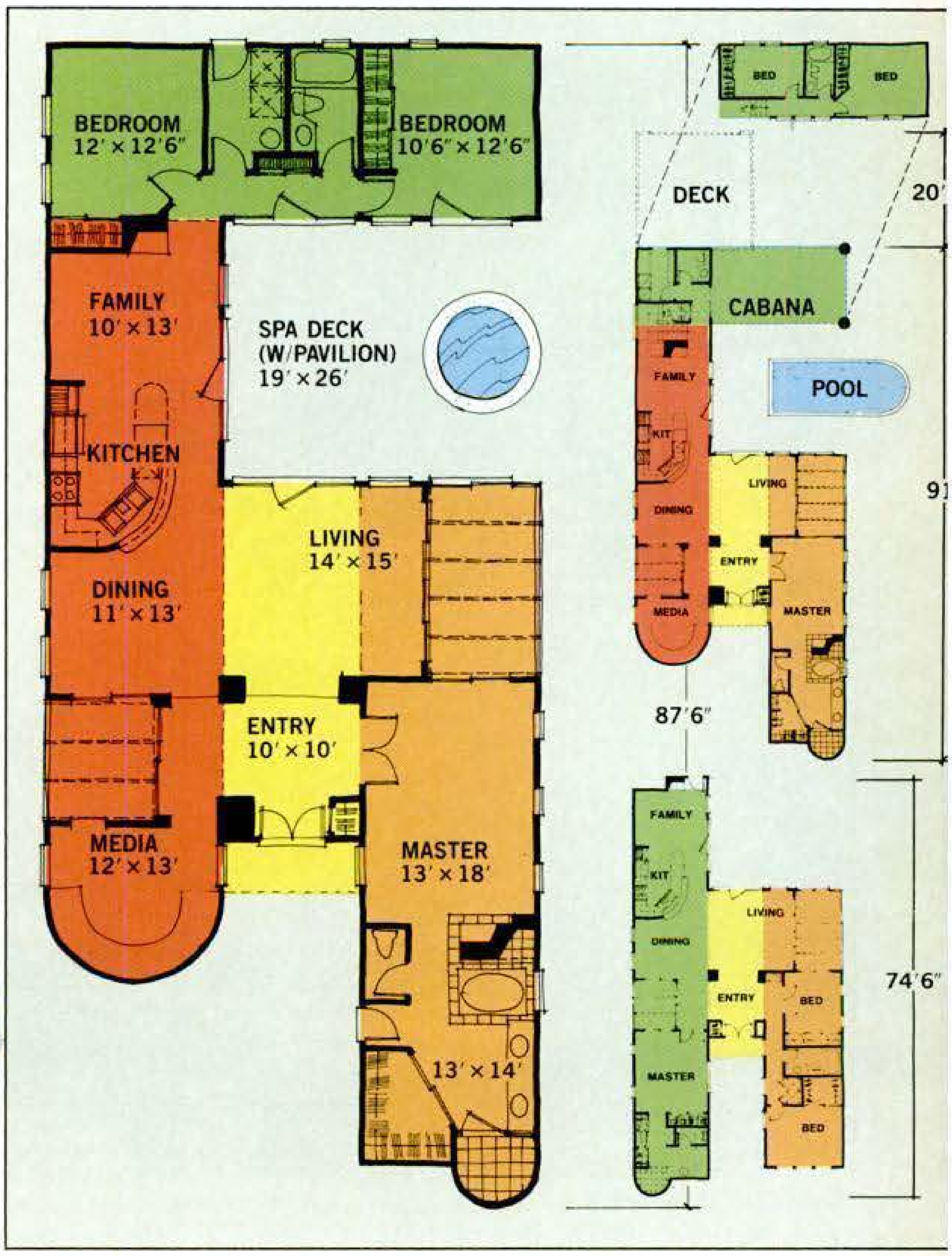


SOUTH



Flexibility of basic design lets you customize the house to your region and your family's needs by shifting the modules to alter the floor plan (three possibilities above) and by changing the shape and siding of the exterior (three variations, left, of the house in top photos). The larger floor plan is for the house shown; the other two are alternates.

Seamless flow from module to module is dramatized by these two interiors, which give no hint of "boundary lines." Top photo was shot from living room toward dining area and open kitchen (sink and range are tucked out of sight behind curved backsplash of work counter). Lower photo was taken from the dining area across three modules and out through lean-to sun space—the home's widest section. All interiors were designed by The Childs/Dreyfus Group.

the May '85 issue of PS ["Shop Talk"], mentioning that Berkus had told me that each module could be assembled in Detroit-style production runs and then inventoried, so that home buyers could go to a housing mart and select the modules needed for a floor plan the size and shape they preferred.

But last year's project, impressive as it was, still bore signs of a building *system*—a kit of blocks that could be arranged to vary the living space within the restraints of the basic, identical-width modules. What distinguishes NEST '86 is that Berkus has reversed his sequence, designing the living space first and adjusting the technology to provide the desired spacial flow. Thus the components are less rigidly structured: Ends and sides of the modules can be omitted or reshaped so they can plug together without structural partitioning.

Berkus conceived of the open kitchen as the command center around which the house is laid out. And he hasn't limited himself, this time, to identical modules: Although the standard width is 13 feet, four inches (as wide as you can comfortably trailer over most roads), the entry module is conceived as an expandable box that can vary in width from six to 14 feet, to adjust to narrow or wide lots. The width chosen for this module sets the total width for the front of the house: It contributes to the living room and supplies the entry. As the larger tinted floor plan (previous page) shows, the balance of the living room, including its sun space, is built into the 13-foot-four-inch-by-56-foot-six-inch master-bedroom module, while the dining-room area is part of the longest module—over 59 feet in the display house—and contains a half-round media room, as well as the kitchen and family room.

The rear module, set at right angles to the others, measures 13 feet, four inches by 37 feet; it provides two additional bedrooms (one could be a home office, instead) and defines the patio, which, in the display house, sported a sunken spa under a pyramid canopy supported by four columns—a private temple to alfresco indulgence (see photo). If I sensed any excess during my tour, it was in response to the *three* whirlpool tubs bubbling away: In addition to the spa, which could easily accommodate a quartet of sybarites, there is a large bubbler just off the master bedroom and a smaller one in the back bathroom. Incidentally, the smaller of the two half-cylinders flanking the front entrance encloses a spacious shower stall in the master bath—a delightful design detail.

The ceiling height through the house varies from eight to just over 11 feet, and at no point do you experience that "economized space" often associated with modular homes. Yet space is efficiently utilized—especially in the smaller rooms. Much of the furniture and cabinetry is built in, and the rear bedrooms feature Murphy-type beds to free the floor space when they're not in use.

NEST '86 truly integrates modular housing with its surroundings. Virtually wherever you stand inside, you have a view outdoors. In this way, the house makes full, active use of its lot, no matter how small. The prototype was planned as a 37-foot-wide, 2,218-square-foot house on a 40-foot lot. It can be produced as a modular, panelized, or component-built home.

The prototype was built by an Austin, Texas, company, using its own standardized panel and truss systems. The house was then broken down into the four modules (with unsupported gaps temporarily braced) and trucked to Dallas for reassembly inside the hall. Architect Berkus tells me he anticipates national availability as regional franchises are negotiated. Meanwhile, you can obtain further information on NEST '86 by writing to Berkus Group Architects, 223 E. De La Guerra St., Santa Barbara, Calif. 93101. It's a house worth investigating. PS

Purify air the space-station way: with plants

Venting air through a sun room full of common houseplants could lower indoor pollutant levels, says a NASA scientist who investigates biological methods of keeping space stations healthy. Now he's rigged his own energy-efficient house accordingly.

By NAOMI J. FREUNDLICH

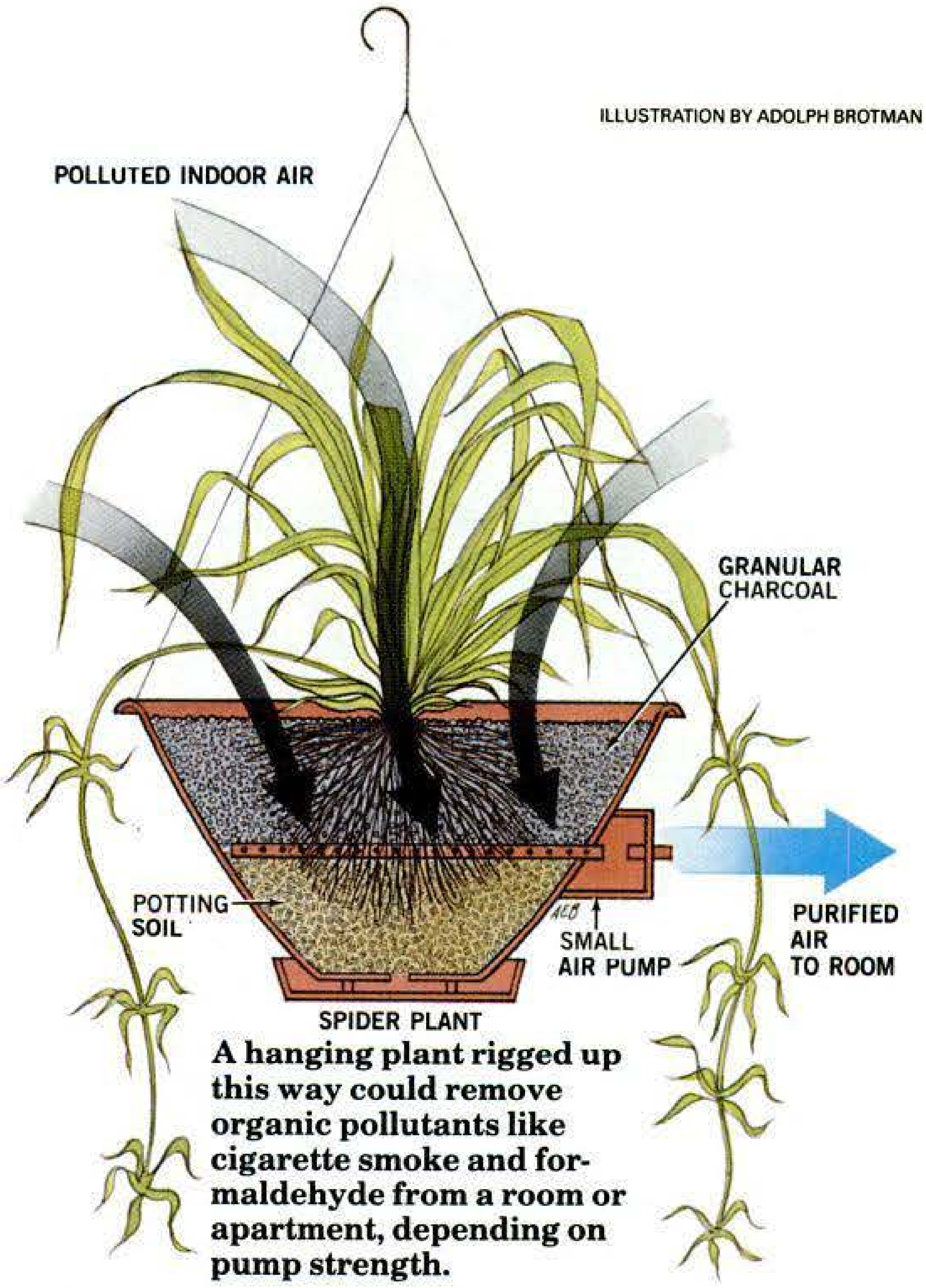
B. C. Wolverton is breathing easy these days, now that he's equipped his energy-efficient house with an air-purification system. Maintenance of the system is simple: a good watering twice a week and an occasional dose of fertilizer. The main component of his filtering system is a decorative solarium stocked with plants.

It may sound a little primitive, but Wolverton, an environmental engineer at NASA's National Space Technology Laboratories, developed the plant-based air-purifying system for the proposed U.S. space station. His research shows that some houseplants, especially the spider plant and philodendron, remove formaldehyde and carbon monoxide (potentially dangerous gases that accumulate when there is low air exchange) from ambient air. Energy-efficient houses almost always have low air-exchange rates and occasionally have pollution problems.

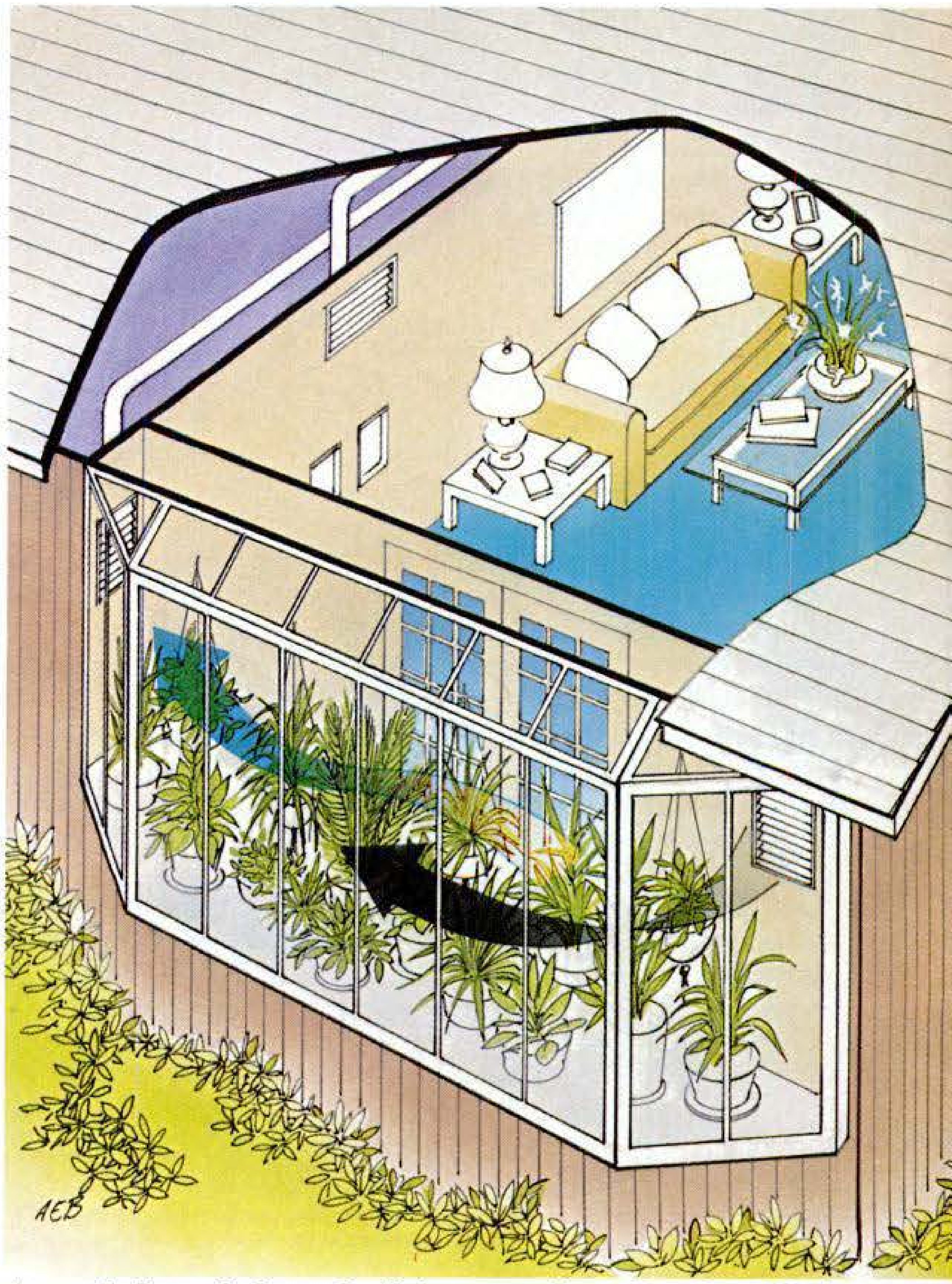
Wolverton is not sure, but he thinks that when the plant leaves photosynthesize, they metabolize these gaseous pollutants as they do carbon dioxide, breaking them down into harmless oxygen and water. Intrigued by this, Wolverton built his own solarium and put 15 to 20 houseplants in it, enough, he says, to purify the air for an 1,800-square-foot house. Although Wolverton didn't check gas levels before building the sun room, he did afterward, and reports no measurable formaldehyde in his home. "The plants also put a lot of moisture back into the air that is removed by heat in the wintertime," says Wolverton.

For those who don't have the space or money for a solarium, Wolverton has another idea that takes advantage of the natural filtering abilities of plant roots. He suggests using hanging spider or philodendron plants—potted in a mixture of soil and granular charcoal—as mini-filters for offices or apartments. A small air pump hidden in the decorative pot pulls air past the roots every hour or so (see drawing). Organic pollutants are absorbed by the charcoal, where root microorganisms degrade them. PS

ILLUSTRATION BY ADOLPH BROTMAN



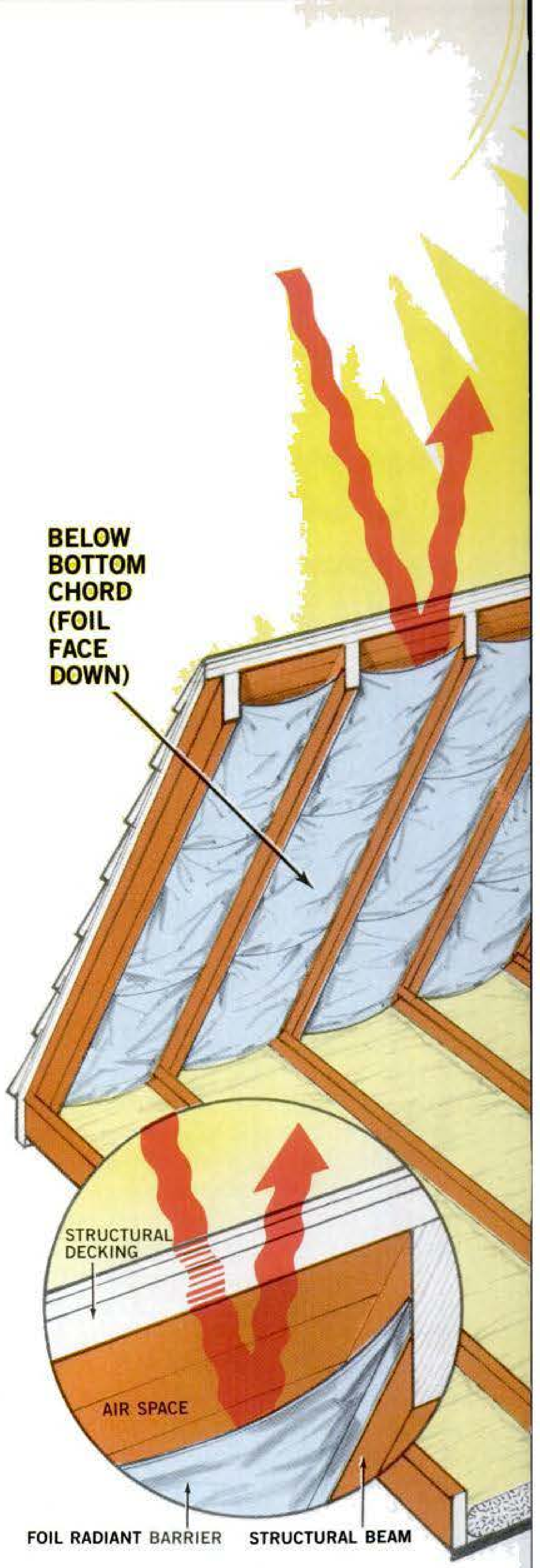
A hanging plant rigged up this way could remove organic pollutants like cigarette smoke and formaldehyde from a room or apartment, depending on pump strength.



A vent brings air from the living room into this plant-filled sun room. Twenty minutes later the air is delivered, pollutant-free, to the central heating unit.

Foiling the summer sun

Scientists say that most of the heat gained by a house during the summer is thermal radiation transmitted from the hot, sunlit roof. Tests now show that radiant barriers—shiny aluminum-foil surfaces in attic air spaces—can cut air-conditioning bills in hot climates by reflecting this far-infrared radiation back out the roof. Still, the benefits claimed for these foil products continue to be controversial.



By STEVEN ASHLEY
Drawings by Adolph Brotman

The sun had just broken through the cloud cover as Philip Fairey and I ambled past the Florida Solar Research Center's rather curious collection of test houses near Cape Canaveral. Fairey, a senior research scientist at FSRC (which is administered by the University of Central Florida), pointed to a somewhat misshapen-looking house enclosed by an exterior metal frame. "This house," he said, "has an outside frame that will support whatever structural changes we make for testing." We entered the house and climbed into the attic through a trap door in the ceiling. Fairey pointed again. "There's our Passive Cooling Laboratory."

It wasn't much to see: a closed-off attic space with thermometers and airflow meters protruding from the walls and heat-flux meters imbedded in the ceiling to monitor what happens inside. But this sealed attic was the key to recent experiments by FSRC researchers designed to demonstrate the efficacy of attic radiant-barrier systems—layers of aluminum foil installed in air spaces that reflect summer heat out of houses.

As I crawled over the rafters, inspecting the sealed test cell, the sky outside brightened and the heat inside grew steadily until my shirt was soaked with sweat. "This entire attic should be lined with radiant barriers," I told him jokingly. "That's what I keep telling everybody," he replied, smiling.

For years the effectiveness of radiant barriers has been the subject of an ongoing debate. Recent investigations by Fairey and his colleagues, as well as by researchers at other institutions such as the Tennessee Valley Authority and Oak Ridge National Laboratory, have shown, however, that radiant barriers significantly reduce summer heat gain in insulated attics, and thereby reduce cooling costs. But no accepted test for measuring the effect of these products has yet been approved by building-material-standards organizations. Thus the precise amount of benefit has remained an open question.

The controversy came to a head this spring when the Florida Department of Community Affairs called a meeting at which representatives of manufacturers of both mineral-insulation and foil radiant-barrier products squared off. The subject: a proposed Florida Energy Code that would allow builders to gain "energy-efficiency points" by installing radiant barriers in attics. Current measurements of the effectiveness of foil barriers, say mineral-insulation makers, have been incorrectly interpreted to portray foil products as being equivalent to mass insulation. "The code assigns R-values [measurement of insulation effectiveness] to radiant-barrier systems by improperly allowing a mass-insulation R-value trade-off for radiant barriers," says Ken Mentzer, vice president of the Mineral Insulation Manufacturers Association.

The debate may stem largely from the fact that radiant barriers work differently from conventional insulation. "Everyone here places too much emphasis on R-values," Freel Singleton, president of AAE Systems, a radiant-barrier manufacturer in San Diego, told me later in a hallway. "R-values are based on conductive heat transfer, but foils stop far-infrared or long-wave *radiation*, so they have practically no R-values. Radiant barriers act more like window awnings than mass insulation."

Just how good is a foil barrier? I spoke with Fairey and other leading radiant-barrier investigators to learn what the latest research says about these foil products and their use.

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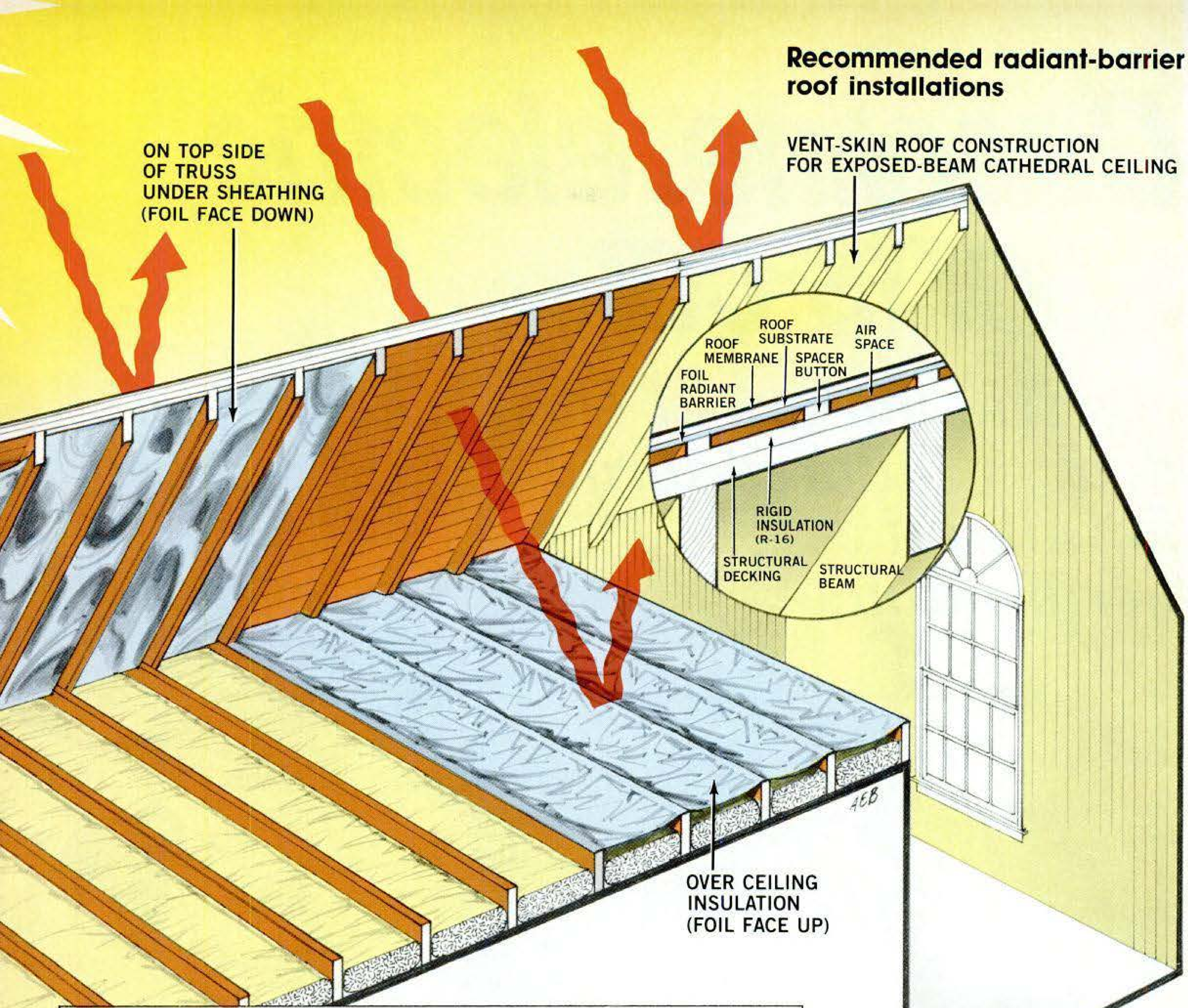
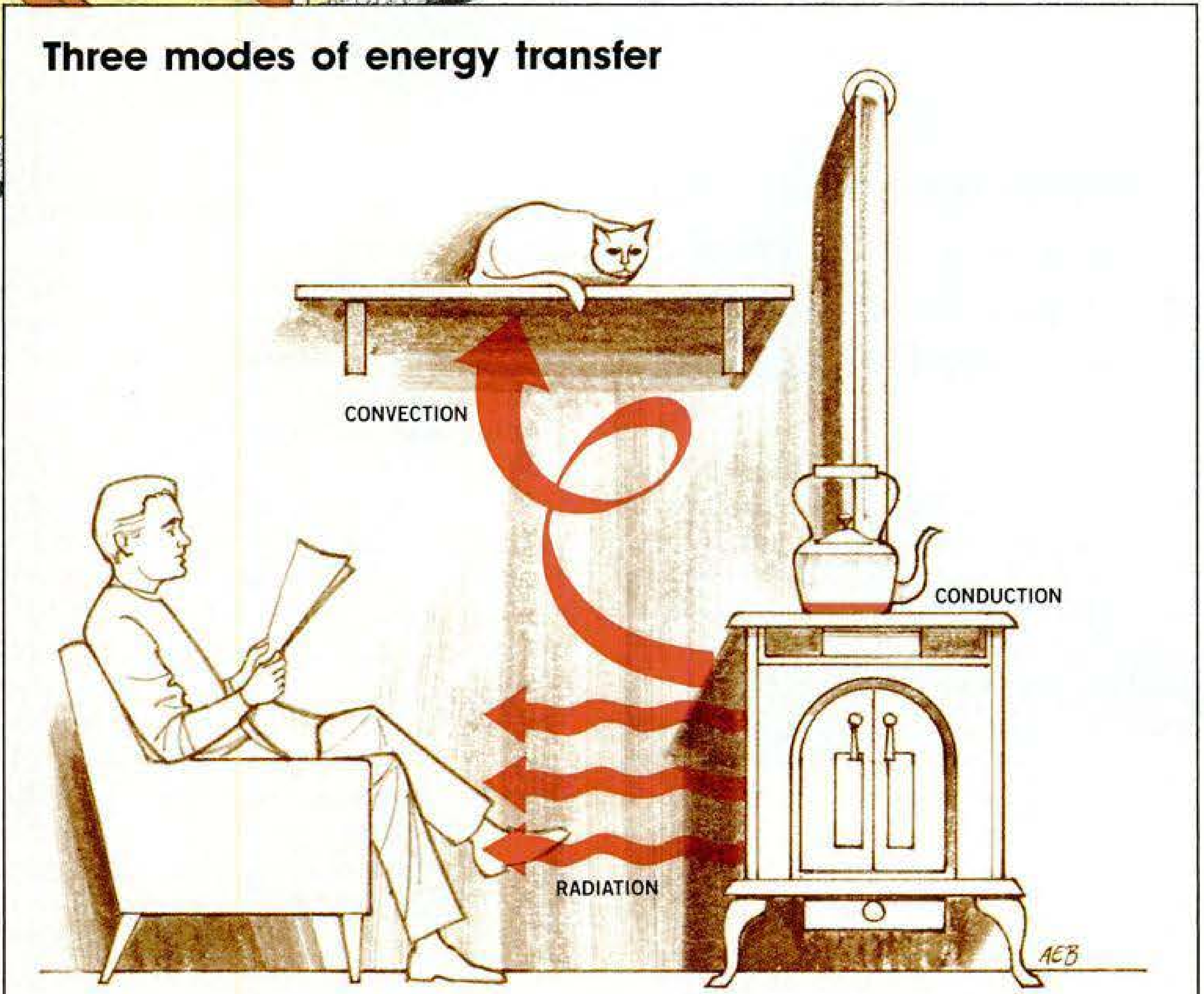


Recommended radiant-barrier roof installations

ON TOP SIDE OF TRUSS UNDER SHEATHING (FOIL FACE DOWN)
VENT-SKIN ROOF CONSTRUCTION FOR EXPOSED-BEAM CATHEDRAL CEILING
ROOF MEMBRANE
ROOF SUBSTRATE
AIR SPACE
SPACER BUTTON
FOIL RADIANT BARRIER
RIGID INSULATION (R-16)
STRUCTURAL DECKING
STRUCTURAL BEAM
OVER CEILING INSULATION (FOIL FACE UP)
AEB

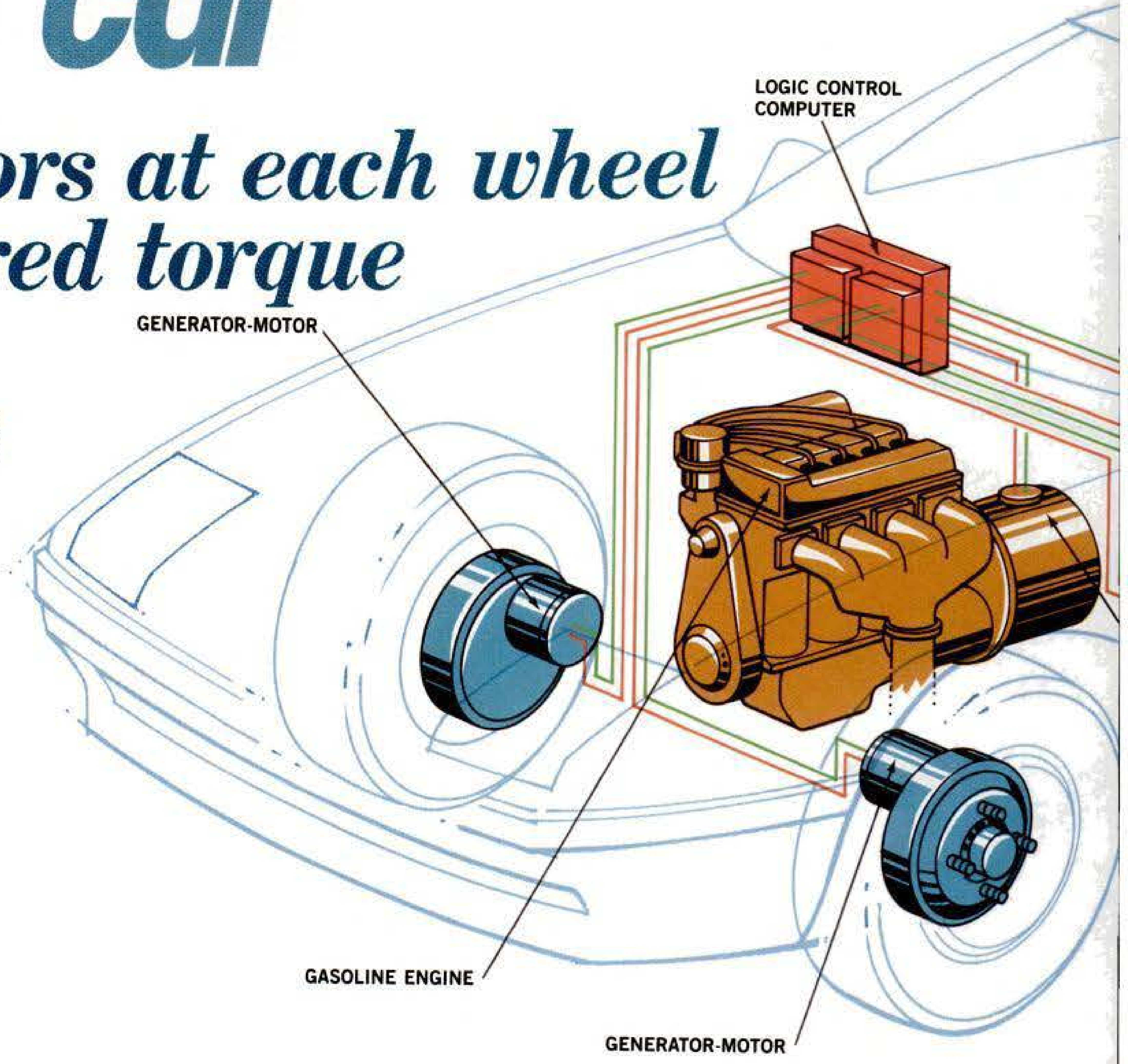


Three modes of energy transfer

Heat travels through a house in three ways (left), and different methods to halt its progress are required. Mass insulation products retard the passage of *conductive* heat; radiant barriers reflect thermal *radiation*. Four radiant-barrier installation techniques recommended by the Florida Solar Research Center are shown above. From the left: between the rafters, just below the roof decking, over the ceiling insulation, and in cathedral ceilings. To vent the first two examples, make sure that the foil droops about 1 to 2 in. from the roof decking. The barrier should also extend to about 1 in. from the roof peak and as close to the soffit as possible. Installation over ceiling insulation is less favored because dust buildup will cause heat to be conducted through the aluminum-foil products. In this case, use perforated barriers to allow vapor to escape. The radiant-barrier air space in the cathedral ceiling should be vented only in climates with small heat loads.

Gasoline/electric sports car

—electric motors at each wheel deliver tailored torque for all-out performance



A small development company in Denver is working to eliminate the automobile's transmission, gears, and drive shaft. With this totally new system, the engineers hope to achieve sports-car-like performance with 100-mpg fuel economy.

By DAN McCOSH
Detroit Editor

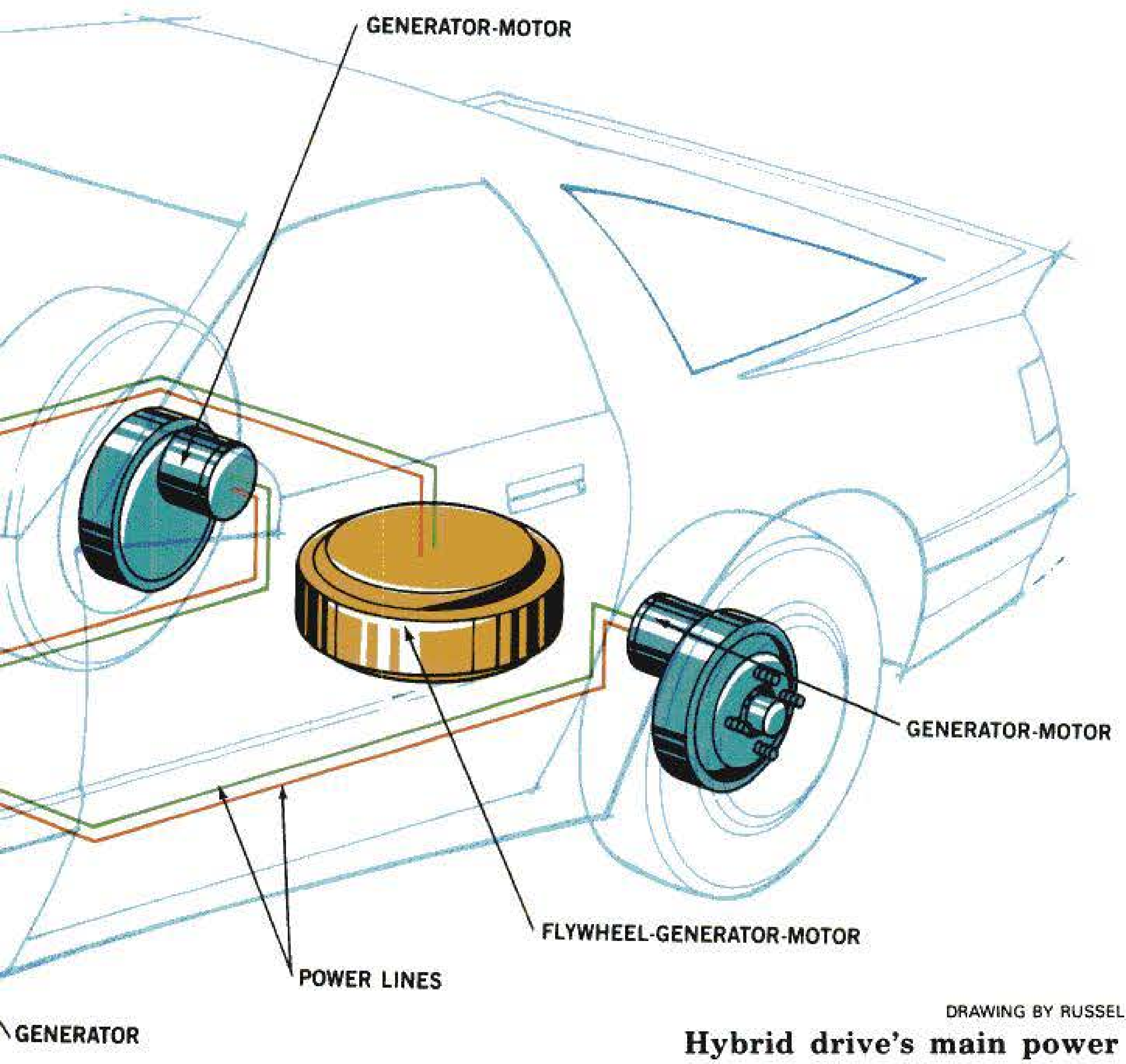
If Ray A. Geddes has his way, the street racer of the future will no longer rev his engine in noisy preparation for a stoplight blastoff. Instead, he'll sit quietly while his tiny constant-speed engine powers up an energy-storage flywheel in near silence. Then, as the light changes and he snaps his foot down on the accelerator, a flywheel/generator will release a massive surge of power to electric motors located at each wheel. Within seconds, the hybrid-drive racer will be a small dot on the horizon.

Since the beginning of the automobile age, power has been transferred from engine to wheels through drive shafts and transmissions. The goal with the new system is to break with that tradition entirely and convert the raw energy of an internal combustion engine—still the lightest, most efficient source of on-board power for a car—into electricity that powers a motor at each wheel. Such a system, if it can be made to work, would produce a host of benefits:

- Nearly infinite torque control, applying precise amounts of power at each wheel according to demand and road surfaces.
- Outstanding economy—in the range of 100 mpg—both at highway speeds and in stop-and-go driving.
- Regenerative braking, in which the energy now dissipated as heat would be used instead to rev up a flywheel, and then be extracted again for the next acceleration cycle.

But if there are potential benefits, there are also big problems. Among them: Conventional electric motors are massive and heavy, and the electronics to control the relatively high currents with the necessary precision doesn't exist.

So is this another automotive fantasy, an idea to be shelved along with the car that runs on water and the James Bond specials? I recently visited a small development company called Unique Mobility, run by a couple of former Detroit heavyweights, which just may have come close to solving the problems and converting the idea into reality. And more: Rather



DRAWING BY RUSSELL VON SAUERS

Hybrid drive's main power sources are an engine-driven generator and an energy-storage flywheel. At constant speeds, the generator will power small electric motors at each wheel. During peak power demands, an on-board computer will pull power from the flywheel for the wheel motors.

than pursuing a fantasy, Unique Mobility may be running only slightly ahead in a race to apply recent breakthroughs in high-strength magnets, electric motor design, and power semiconductors to a new generation of power transmission.

The moving force behind Unique Mobility is chairman Ray A. Geddes, who draws confidence from a 28-year automotive background that includes a stint at Ford supervising the team of Shelby Cobras that unseated Ferrari for the world championship in 1965. Geddes later worked with specialty-car programs, including the Ford GT 40 race cars that swept LeMans, and the original Shelby Mustang GT 350. His former mentor, Carroll Shelby, today is a major stockholder in Unique Mobility and sits on the board of directors.

The essential concept Geddes has been working on is an engine-driven generator powering electric motors at the wheels. Engineers call the concept "hybrid drive." It's not a new idea; a car called the Gas-A-Lec was on the market in 1905 that used an engine-driven generator coupled to an electric motor at the wheels. An automotive hybrid-drive system is basically a shrunken version of the diesel-electric drive used on locomotives and big earthmoving equipment. Hybrid drive promises numerous benefits—mainly near infinite control of speed, torque, and power at the wheels, while a small engine providing power runs steadily at a constant and efficient speed.

Today's on-board computer controls promise a whole series of benefits from hybrid systems. Even the simplest possible hybrid drive—an engine-driven generator coupled to a drive motor —becomes a promising route to a lightweight, infinitely controllable automatic transmission.

Geddes is staking his dream on an extremely lightweight, powerful new permanent-magnet electric motor developed by Unique Mobility that produces up to 40 hp in an eight-pound package. It's one of a new generation of small, powerful permanent-magnet motors. Coupled to power logic systems that allow the motors to be directly controlled by computers, the hybrid-drive system, Geddes says, can substitute for conventional mechanical and hydraulic transmission systems. Potential applications of hybrid drive in automobiles range from powering engine accessories to one of the most flexible, efficient, and responsive transmission systems ever conceived.

In an operating system, a computer senses the torque and speed demands of the car, feeding power to the driving motor on demand. It's a kind of electronic version of a standard automatic transmission, which uses a hydraulic torque converter and hydraulic logic to accomplish the same task.

"It's the ultimate constant-velocity transmission," says Geddes. "The drive motors start at zero from a standing start, and are controllable over the full range of vehicle speed. No mechanical system even comes close."

Geddes sees even further possible benefits to hybrid drive in an automobile: eliminating conventional gearing altogether. "A separate motor driving each wheel would allow you to control torque individually under all driving conditions. Say in a high-speed corner, when the car loads up the outside wheels, torque is applied to the wheels with the most traction," he says. More sophisticated traction control would cut power to a wheel spinning on ice, directing it to a wheel on dry pavement.

The full program Geddes envisions includes an energy-storing flywheel that accumulates energy from regenerative braking and low-demand periods, to release on demand for acceleration. Taking advantage of an electric motor's ability to act as either a generator or motor, Geddes proposes a flywheel that consumes electricity to wind up to speed, and then generates current when the electricity is needed.

With the car at speed, tapping electricity at the wheels to spin up the flywheel makes the wheel motors act as brakes—completely controllable with anti-lock sensors. The spinning flywheel then supplies short bursts of power to accelerate from a standing stop. Saving the energy normally dissipated as braking heat increases the overall efficiency of the car; theoretically, stop and go should consume no more fuel than steady highway speed.

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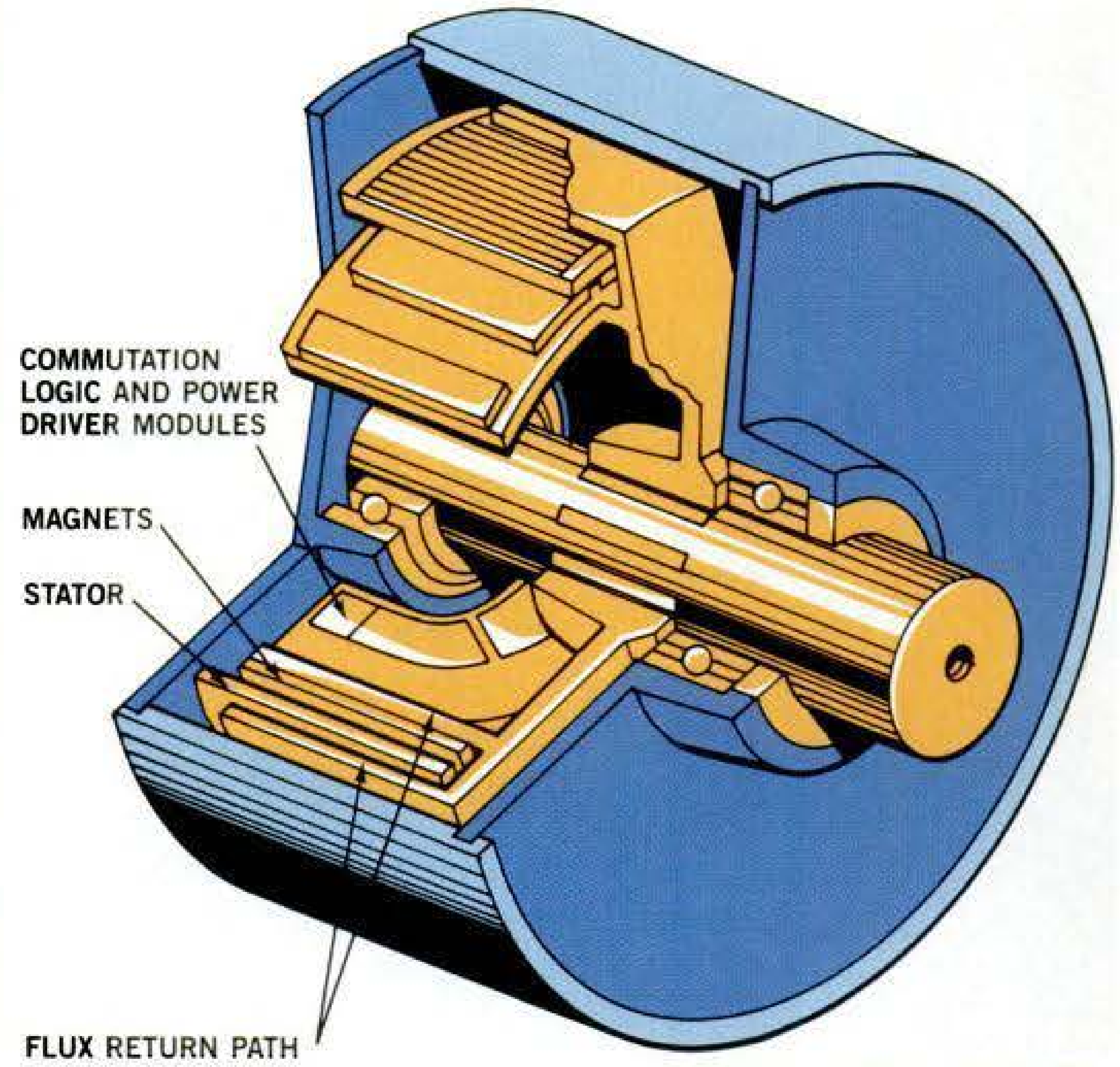
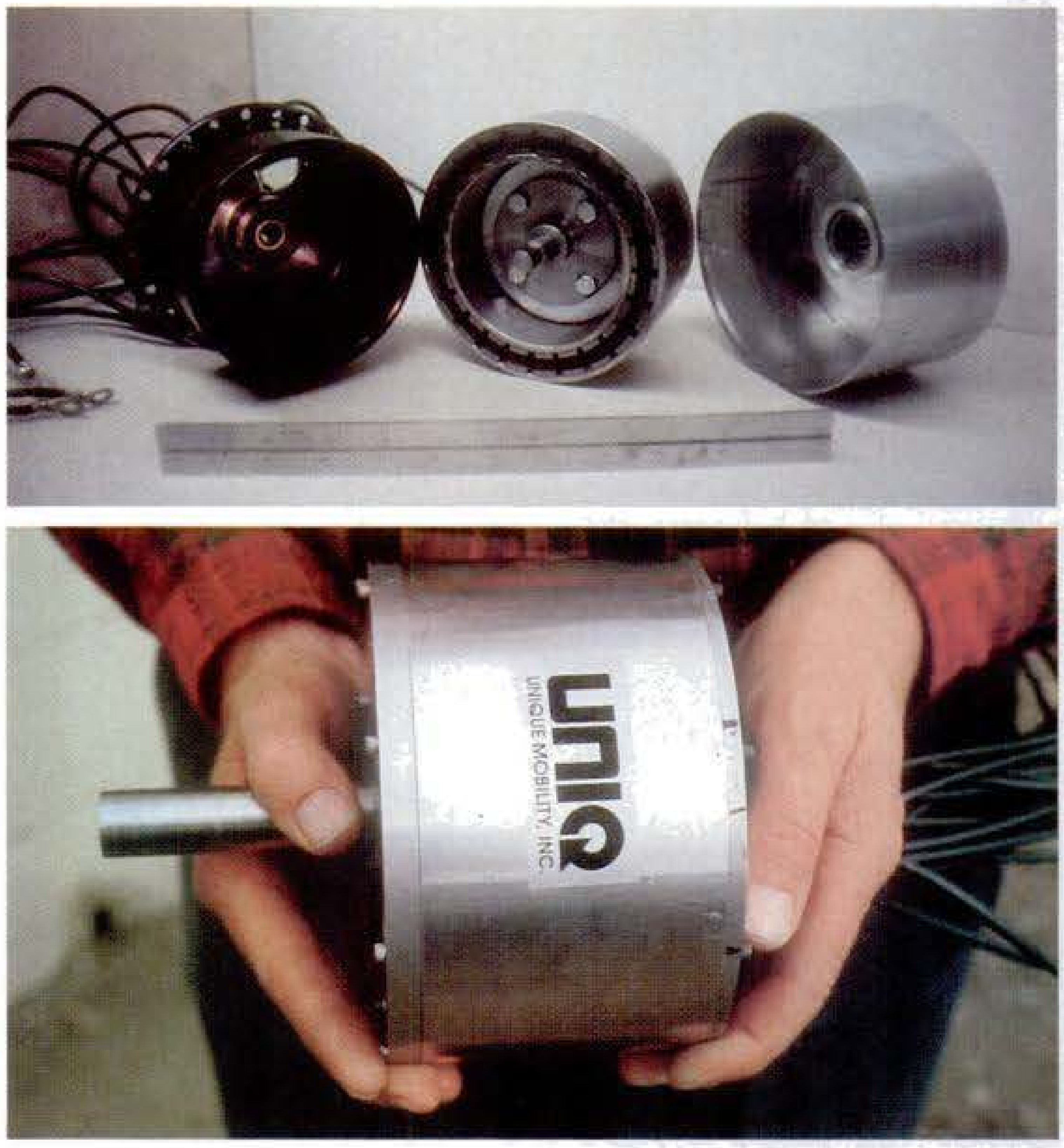


DRAWING BY RUSSELL VON SAUERS



Unique Mobility's 8-lb., 40-hp traction motor is shaped like a cake pan turned on edge. It's actually two cups that nest inside each other. One holds a row of neodymium permanent magnets on its rim. The other cup carries a belt-shaped wound armature. Conventional motors of equal power weigh between 240 and 255 lbs.

In addition, with the flywheel accommodating power surges, only a small engine is needed to supply the average power to the system—a boon to overall fuel economy.

Now the problems

But what works on a locomotive has been impractical for passenger cars. Three key problems have held this system back: the electrical inefficiency of today's best motor-generator sets, the sheer bulk and weight of today's electric motors, and compact high-power electronics to handle the motor-control requirements.

"One problem is that the average efficiency of a reasonable size motor is only about eighty percent," explains Dr. Victor Wouk, a New York-based consultant on hybrid drive. "That means with the losses in a motor and generator, you start losing about a third of the advantage—unless you use very big engines and very big motors."

In addition to the problem of electrical inefficiency, the weight of a motor-generator set powerful enough to propel an automobile has limited its practicality. One of the best commercial 32-hp DC traction motors on the market today weighs some 240 pounds. Conventional AC motors cut the weight to 75 pounds or so, but still represent considerable bulk. Anyone with a standard ¼-hp motor driving a grinding wheel in the home workshop can appreciate how bulky an electric motor can be.

At Unique Mobility's Denver headquarters, Gene Fisher, vice president of research and development, tossed me the guts of a 1-hp motor he had designed; I caught it with one hand. I was holding what looked like an empty toilet-paper roll with fine wires imbedded in the surface. Fisher calls it a "shell," or "cup," motor. It weighs less than a pound, can produce 1 hp, and can rev to 2,500 rpm in 0.5 milliseconds.

Fisher developed the motor to power a high-speed computer tape drive. Now he is expanding on the concept to build motors large enough to power cars. Unique Mobility's eight-pound 40-hp traction motor is considerably shorter and fatter than the tape-drive motor.

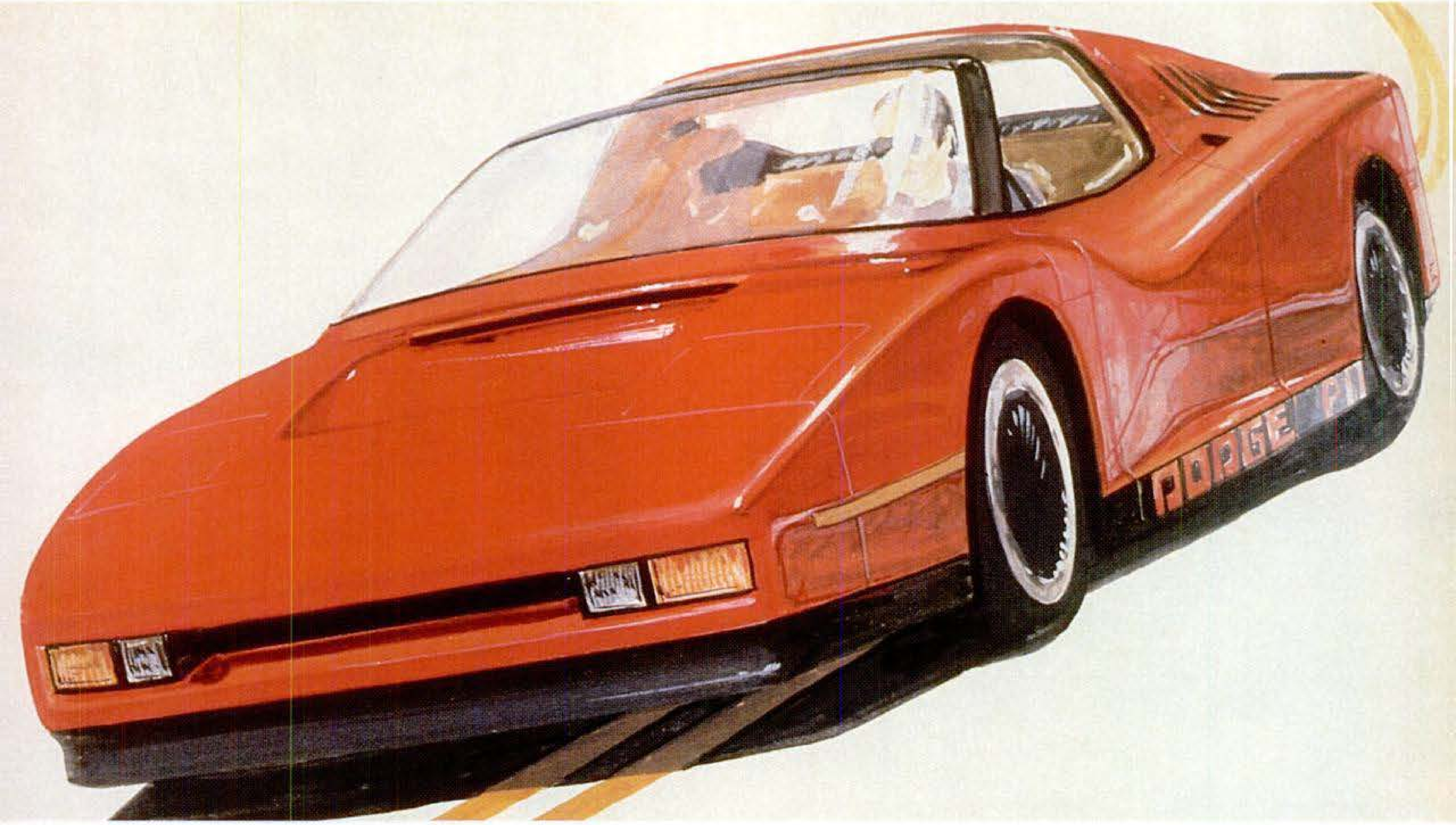
"You can spend forever trying to improve existing designs ten percent," says Unique Mobility president John S. Gould. "We took the basic principles of motor design and started from scratch. That improved everything —even simplified the controller design."

"The breakthrough is the ability to use very high-strength permanent magnets," says Wouk. "They have a very high flux density, producing larger force, greater torque, and higher speed. But there are a few tricks to using very high-strength magnets," he adds. The permanent magnets used in the motor are neodymium—one of a new generation of supermagnets that are 10 to 40 times as strong as ferrite magnets, the most common in use today.

Fisher says several engineering features contribute to the motor's power: Extremely thin armature windings are located far from the center shaft, increasing their effective torque. The close spacing of each winding to the permanent magnets means the propulsive force is maximized. Also the thin windings help dissipate heat.

Smooth control of high horsepower is a problem with most motors, which would rather be "off" or "on." The new design actually has three sets of windings in layers—one on top of another —each powering the motor at certain speed range. The controller "shifts gears" by going from one winding set to another. "We should be able to develop the forty horsepower at about 2,500 rpm. It's not strictly a high-speed motor," says Geddes.

Like most permanent-magnet motors, the Unique Mobility system functions efficiently as either a generator or motor. "To make the flywheel, we weight the 'cup' of the motor, make it wider and flatter, and it becomes a flywheel storage system, about the size



Hybrid drive's inherent flexibility allows a front-, mid-, or rear-engine position for swoopy low-nose designs like this one.

of a mini spare tire," says Gould. An early prototype weighed 250 pounds, but Gould notes most of that weight was heavy shielding installed to catch pieces if it broke.

"We were running it over 25,000 rpm and we thought it might explode," he explains. Later generations will be lighter and slower. "A small flywheel would store about one-sixth kilowatt-hour of energy, a real wheel-burner a full kilowatt-hour," Gould says.

What's a MOSFET?

The third major obstacle to automotive hybrid drive has been affordable and compact control electronics for the complicated switching duties. Fortunately, the new on-board computers promise a whole series of benefits, including smooth motor control. Electronic controls for the motor are based on a new generation of semiconductors called a Metal Oxide Semiconductor Field Effect Transistor (MOSFET).

"MOSFETs can switch high power at high frequency, while being controlled by low voltages," Geddes says. "They were developed in the 1970s, but just recently there have been major increases in power handling capability." The Unique Mobility motor uses four MOSFETs in parallel to handle its 120-amp/200-volt demand. Each MOSFET is about the size of a one-inch cube.

Controlling the MOSFET is the job of the microprocessor. It's programmed to respond to throttle position and sensors signaling engine power loads, wheel spin, and torque requirements.

Today, the pieces that would make the "supercar" work exist, but only on the workbenches at Unique Mobility. The development program to get the sports car project on the road would mean taking the basic pieces—the motor, flywheel, and controller—that are still in Unique Mobility's lab and developing them to where they could stand up in automotive use.

The full potential of the new motor has not yet been achieved, Gould says. Sustained tests have been run at about 20 hp, half its theoretical rating. But this is still an impressive output. A control system is also in the development stage.

Possibilities for Geddes include support by a major British sports-car manufacturer, underwriting a three-year project to develop a 130-mph sports car and put his dream on the road.

But first, hybrid drive is likely to show up in less ambitious roles than a full-drive system. One potential application is direct electric drive and control of engine accessories, including the water pump, camshaft, and power steering.

The second place we can expect to see hybrid drive is in military vehicles. Recently the U.S. military became interested in the potential of hybrid drive for all its vehicles.

"They're merging control electronics with power transmission. We call it 'smart power,'" says Patrick McCleer, assistant professor of electrical engineering at the University of Michigan, who recently completed a study on smart power transmissions for military vehicles ranging from tanks to light trucks.

The study indicated that even hybrid drives using currently available technology promise smaller size and lighter weight than today's mechanical and hydraulic transmissions. General Dynamics Corp. (Troy, Mich.) recently completed a prototype medium-truck chassis using a motor-generator set as a transmission, based on the new permanent-magnet motors. Several similar projects are in the research stage.

Development is expected to accelerate quickly, however, as other major manufacturers rush to develop the new generation of electric motors. General Motors launched a new plant manufacturing its Magnequench ["Mighty Magnet," PS, Feb. '85] magnetic material in production volumes only a few months ago, the first volume source in the U.S.

The era of smart power is here.

Here comes DAT

Recording with digital audio tape—DAT—will bring to home recording the clean, noise-free reproduction quality until now available only on compact discs. Home decks are in the laboratory now, and they'll probably be on the market some time next year.

By LEN FELDMAN

"Psst. Come here, Len." The voice called me from behind a blue curtain in one corner of Onkyo U.S.A. Corp.'s exhibit booth at the Consumer Electronics Show in Las Vegas. David Birch-Jones, Onkyo's product manager, spread the curtain slightly and held out a miniature front-loading audio cassette deck.

"Watch this," he said, while pushing a button on the front panel. Out popped an audio cassette. It was about the same thickness as a conventional audio cassette, but about one-third smaller. "You can digitally record two hours of music on it," Birch-Jones said, tapping the blue plastic case with his finger. Then, eyeing the book-size recorder in his hand, the DT-1000, he added, "All you need is one of these. This is a digital audio tape recorder for the home. It's the recording system of the future."

This could be important. Digital technology in the form of compact discs (CDs) has changed our expectations of audio reproduction. Now digital strikes again, promising to eliminate the hiss and noise heard from conventional home audio tape recorders.

Rumors of digital audio tape-recorder development have circulated for years. Now it appears to be past the drawing-board stage. How do these new machines work? When will they be available? How much will they cost? And in view of the promise, why wasn't Onkyo—and everybody else—spotlighting the recorder at the show? Why the cloak-and-dagger atmosphere at my private showing?

To get the answers to these and other questions, I talked with representatives of leading audio companies, including Technics, Panasonic, Sony, JVC, Matsushita, and Sansui. Here's what I learned.

DAT bits and bytes

The principles of digital audio tape recording are similiar to those used to hold music on a CD. To convert an analog signal to digital for recording, it is sampled thousands of times a

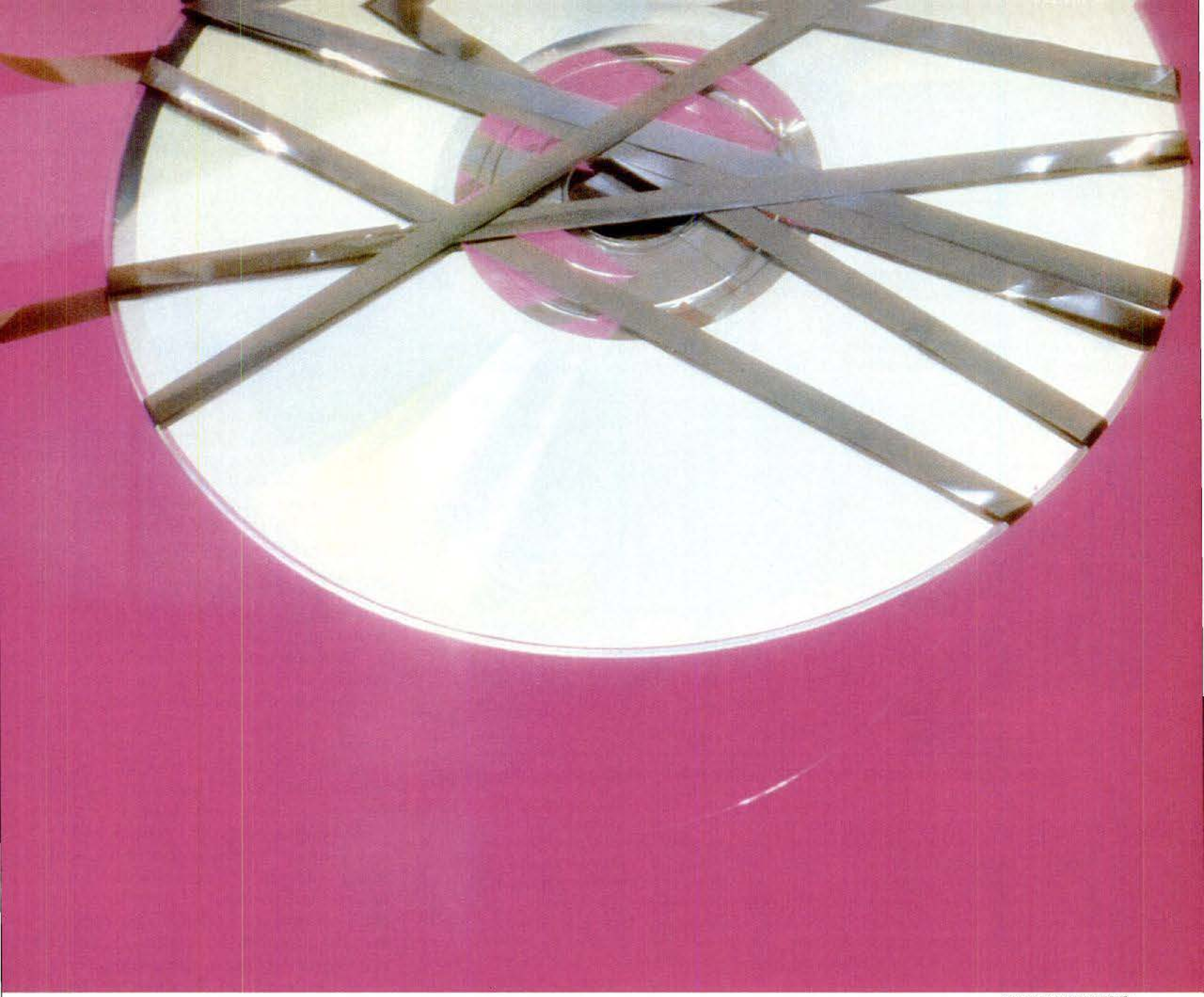


PHOTO BY GREG SHARKO

second. Each sample is assigned a number value; the louder the sound, the higher the number. The number is converted to digital form—a series of 0s and 1s— which is recorded on tape.

During playback, the pulses are read by a playback head and converted to their numerical value, and the value is used to reconstruct the original analog signal. Result: The recording is a nearly exact replica of the original.

Digital tape recording has been used for years by professional recording studios. Their big, expensive digital machines give a lot of advantages. There is no background noise or tape hiss. So long as the playback head can detect the pulses, the low-level hiss —analog random noise produced by tape passing in front of a tape head— is ignored. Because the sound level is recorded as a number—not a varying analog voltage that could reach the limits of the tape—the dynamic range (difference between the loudest and softest sounds that can be recorded) is much greater. With enough digital samples, playback distortion becomes insignificant. Frequency response is within the usual audio limits from 20 to 20,000 hertz.

For the home

Now the advantages of digital tape are about to hit the home market. Since the technology is well known, why hasn't it happened before? For several reasons, I learned. The first one: compatibility. "If home digital audio taping is to succeed," says Marc Finer, product communications manager for Sony Corp. of America, "there must be a single set of standards so that everyone's DAT recorder will be able to play everyone's digitally recorded tapes."

But creating industry standards has taken time. More than 2½ years ago representatives from 81 companies (60 from Japan and 21 from Europe, North America, and elsewhere) sat down in Japan to establish standards for DAT recorders. But at their recent meeting held last July, the members of the Electronic Industries Association of Japan (EIAJ) decided to release specifications for *two* types of DAT recorders: S-DAT (stationary-head digital audio tape) and R-DAT (rotating-head digital audio tape). Will this start another format battle like VHS versus Beta? Probably not.

"The S-DAT format will more than likely be used for professional or studio applications only," says Finer. "R-DAT is the one used by Onkyo, and it will most likely be adopted by other manufacturers as they enter the home-DAT race next year."

At JVC Co. of America's research and development division in Japan, I saw an S-DAT recorder. It uses a special stationary thin-film recording head with high-grade metal-particle tape. As the tape passes by the head, the digital pulses are recorded on 22 separate tracks, each only 65 microns (0.0026 inch) wide. While the technol-

Continued

ogy is admirable, it would be too expensive for the home.

"If we were to go with a stationary-head approach, we'd have to come up with new tape-head technology and better tape formulations," says Almon Clegg, an engineer for Matsushita Electric Corp. of America. "That would result in a much costlier DAT recorder for home use. It might be so expensive that no one would want to buy one."

For that reason, the experts predict that R-DAT will become the home system. A set of spinning recording heads is similar to those used in video recorders (see box). "The industry has gained a lot of experience with precision fast-spinning tape-head drums in VCRs," says Clegg, "and this experience can be put to use with R-DAT machines."

Holding back

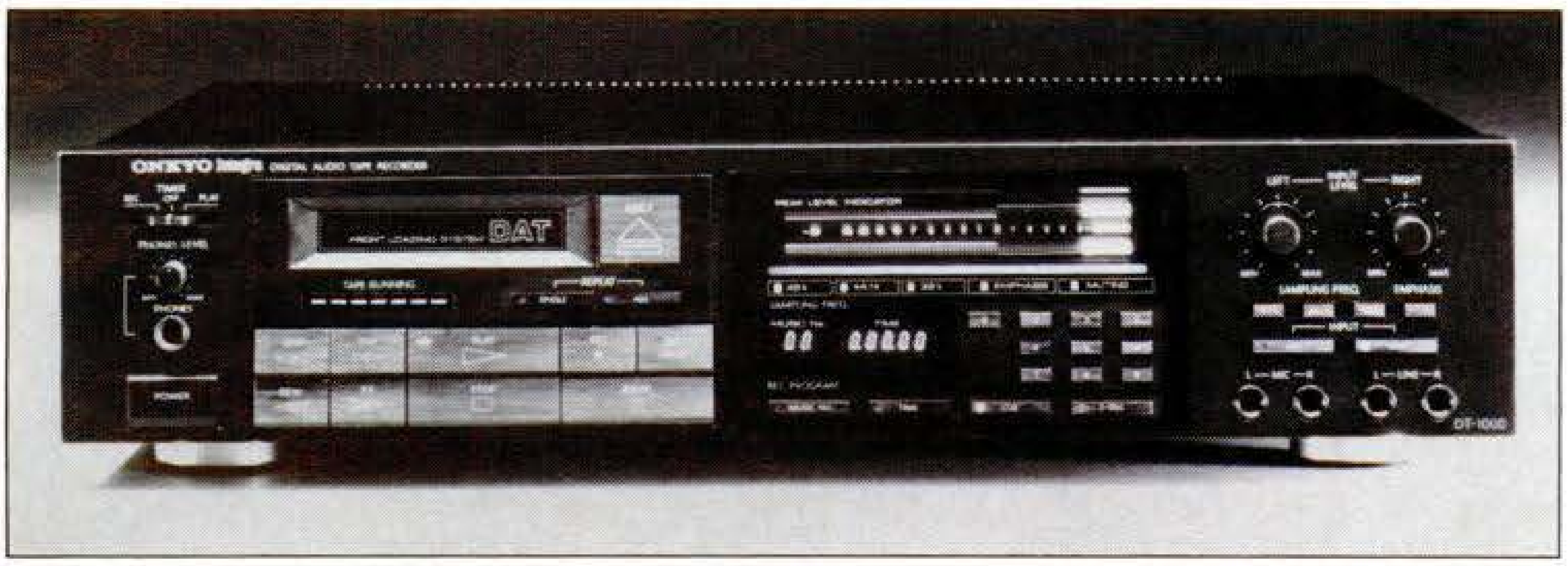
If the basic technology for R-DAT is well known and standards were established a year ago, why haven't we seen machines before this? The answer appears to be marketing strategy.

"Consumers would be very confused if we introduced DAT just now," says Tom Yoda, president of Sansui Electronics Corp. "People are having enough trouble absorbing the new technologies of compact discs, laser video discs, VCRs, camcorders, and more. Once the compact disc has firmly established itself, that will be the time to introduce DAT." The companies are proud of the new development but are afraid of upsetting sales. Some were reluctant to talk about the field at all, fearing that even news of the new products would cause trouble. And this fear, I learned, was the reason for the Onkyo cloak-and-dagger act.

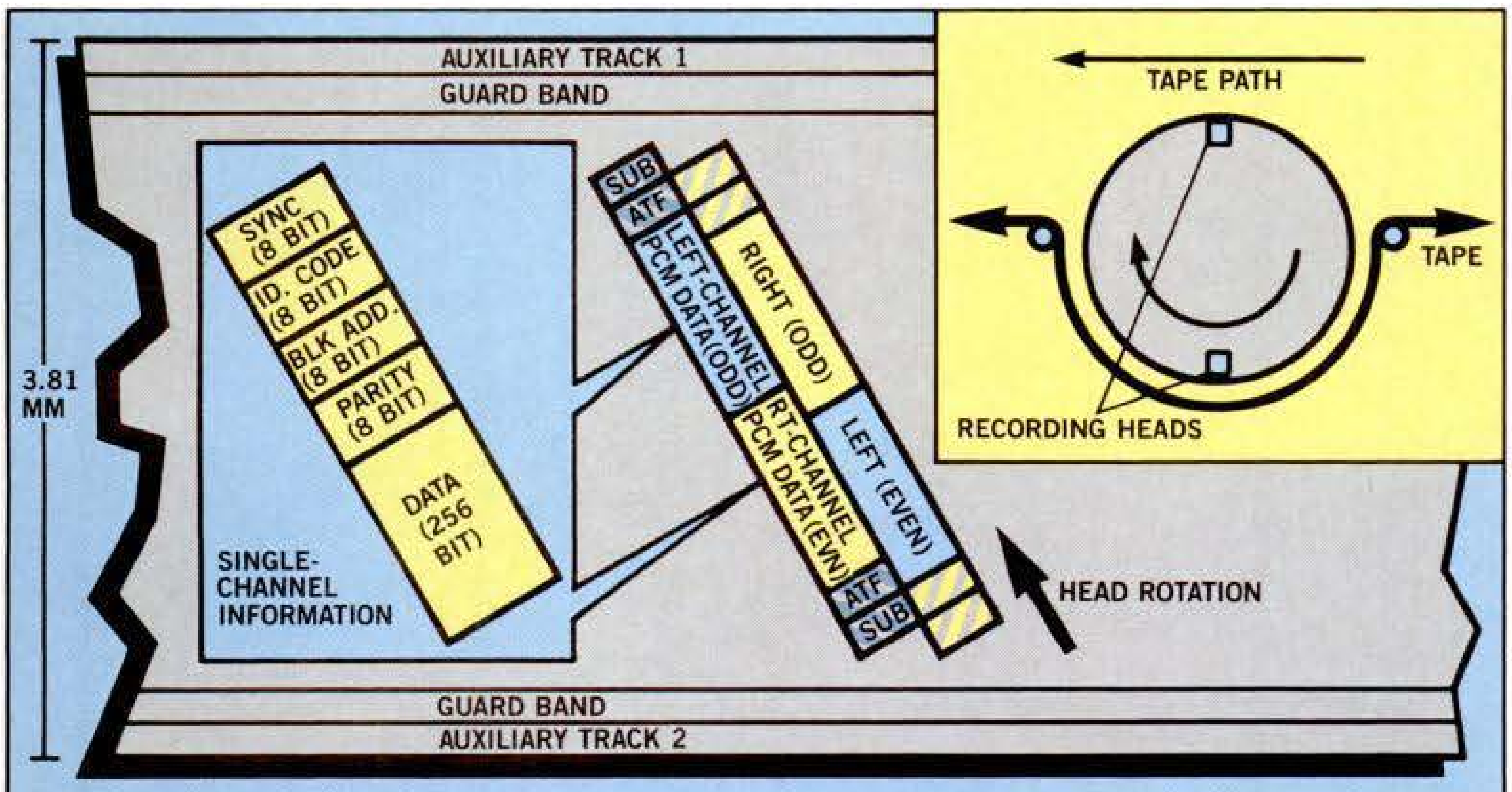
So when will we see the first machines? Definitely not before the end of this year, and it could be well into next year.

Could DATs put CDs out of business? I'm inclined to think not. Each medium has advantages and disadvantages. DATs can both record and play back. CDs are playback units only. But as Sony's Finer points out, CDs have advantages over DATs, too: "CDs give you instant access to any selection. And because nothing touches the disc's surface, there's no wear." I think ultimately the two systems will work well *together*—just as analog record players and tape recorders have done for years.

[Continued on page 110]



Onkyo's DT-1000 DAT recorder could be the first of many machines to be available by next year. The price is not set, but it will be about $1,000.

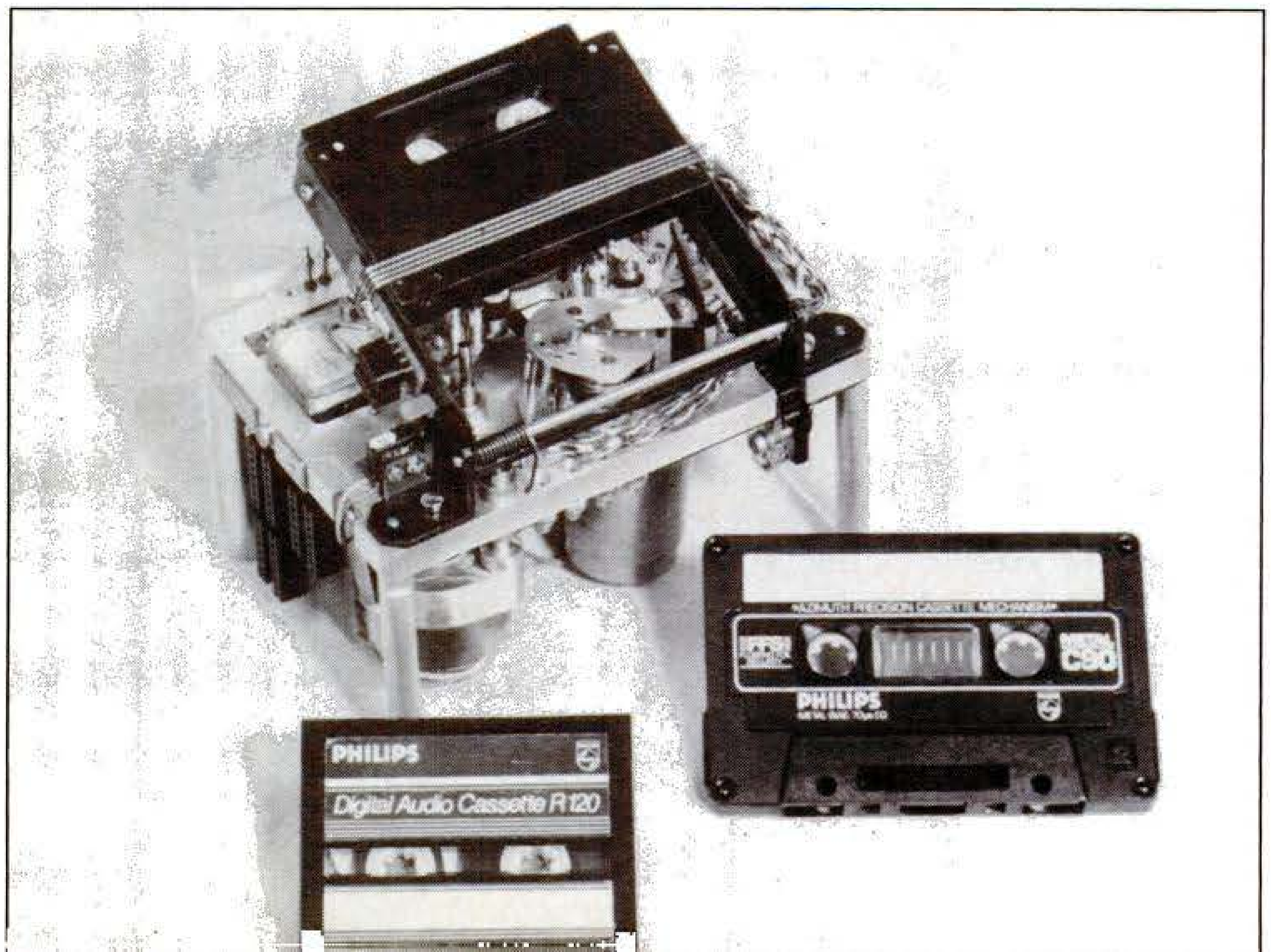


The R-DAT audio recording system is similar to the current 8-mm video recording system. The 30-mm (1.18-in.) dia. rotating drum, spinning at 2,000 rpm, is equipped with a pair of tape heads to record or play separate tracks across the tape. There are five basic data fields per track. The sub-code portions include data for tape time, music selection, indexing, etc. On either side of the main digital pulse-code modulation (PCM) data block are two additional fields called automatic track following. These are used for head-to-tape positioning.

The digital audio data (PCM) portion of the track contains the audio information. The data for each channel are contained in even and odd data blocks. If one of the heads is unable to read data for any reason (such as dirt on the head or tape), the other head will read the reciprocal data and interpolate the missing information.

Because the tape wrap around the head drum is only 90° and the rotating drum contains only two heads, the recorded signal first goes into a temporary buffer memory. The signal is released to the head in blocks when either of the two heads is in contact with the tape. During playback, a similar data buffer memory circuit is used to stretch the data back into a continuous bit stream.

DRAWING BY NINA WALLACE



Prototype Philips R-DAT deck uses the digital audio tape cassette (left). Tape thickness and width are the same as those in a C90 cassette (right).

Solving a century-old problem with Kalina's ingenious engine

Engineers have struggled for years to raise steam-power-plant efficiency—the ratio of heat input to electrical output—by a few percentage points. Recently, an audacious Russian systems designer devised a novel way to squeeze more work out of a heat source, a technique that could lead to a whopping 10-percent efficiency increase. Some experts scoffed, but thermodynamicists now say Kalina's theory is sound. What remains is to prove it out in a real-world plant.

By STEVEN ASHLEY
Drawing by Ray Pioch

"There are literally thousands of valid patents out there on perpetual-motion machines," Alexander Kalina emphasizes with both hands dancing ceaselessly to the Slavic cadence of his discourse. "I come upon them in my consulting work," he says, flashing a mischievous grin and a twinkling eye, "and I place them in what I call my little collection of curiosities." Kalina's enthusiasm for his work in thermodynamics shows in the intensity of his expression.

For the third time in as many minutes, Kalina reflexively draws on the cigarette that dangles from one hand, wipes his brow with the handkerchief clutched in the other, and then apologizes for his heavily accented English. "Is no wonder that power engineers feel uncomfortable when I try to explain my ideas," he begins in a resigned tone. "Look, out of nowhere comes this guy with a bad accent, telling them that if they build a plant his way, they'll get not one or two percent improvement, but ten percent or more. What would you expect?" asks Kalina, throwing up his hands half seriously, half comically.

Ever since the former top Russian energy researcher emigrated to the United States several years ago (he now lives in Houston), Kalina has spent a good deal of time trying to explain the seemingly outlandish notions sometimes associated with his inventions. Now he's promoting an idea that may lead to a revolution in power generation—the replacement of the Rankine steam cycle, the power-generation cycle on which engineers have relied for more than a century. In doing so, the Kalina cycle, as it's called, could save the world tremendous quantities of fossil fuels.

One development that should help convince utilities about the cycle's benefits is a $13 million, 6.8-megawatt combined-cycle prototype plant that Fayette Manufacturing Corp.—the energy company that holds the rights to Kalina's technology—plans to build near Tracy, Calif. Additional reinforcement, says Hank Leibowitz, general manager of Fayette's Exergy division, should come from a $30 million, 20-megawatt direct coal-fired power plant the company is planning to construct in New Brunswick, Canada.

In the Rankine steam cycle, water is heated in a boiler to produce high-pressure vapor, which expands and drives a turbine-generator to produce electricity. The expanded vapor is subsequently condensed and pumped back to the boiler to repeat the cycle. In a direct-fired plant, the Rankine cycle has a heat-to-electricity conversion efficiency of about 35 to 40 percent. In a combined-cycle plant, in which a gas turbine's exhaust heats a working fluid (the "topping" portion of the combined-cycle), which, in turn, expands and spins a steam turbine (the "bottoming" portion), Rankine cycle efficiencies can be as high as 44 percent.

According to theoretical calculations performed by such well-known thermodynamicists as Yehia M. El-Sayed and Myron Tribus (now a board member of Fayette) of the Massachusetts Institute of Technology's Center for Advanced Engineering Study, as well as by analysts in industry, Kalina's proposed cycle will make it possible for a direct-fired plant to transform half of its heat input to electricity. For a combined-cycle plant, the figure is 55 percent.

"To attain these improved yields, I use an old trick that power engineers have known for years," Kalina says. "Instead of one working fluid such as water, I use a mixture of seventy percent ammonia and thirty percent water." Leibowitz explains it this way: "When water is heated, its temperature rises until it reaches the boiling point. Then it stays there until all the water turns to steam. After that, more heating raises the steam's temperature and expands it. When heated, the ammonia-water mixture acts in a different way: First, mostly ammonia boils off, leaving a higher concentration of water in the mixture. As the mixture's composition constantly varies, so does its boiling point, which allows its temperature rise to better match the steadily increasing temperature of the combustion gases. This

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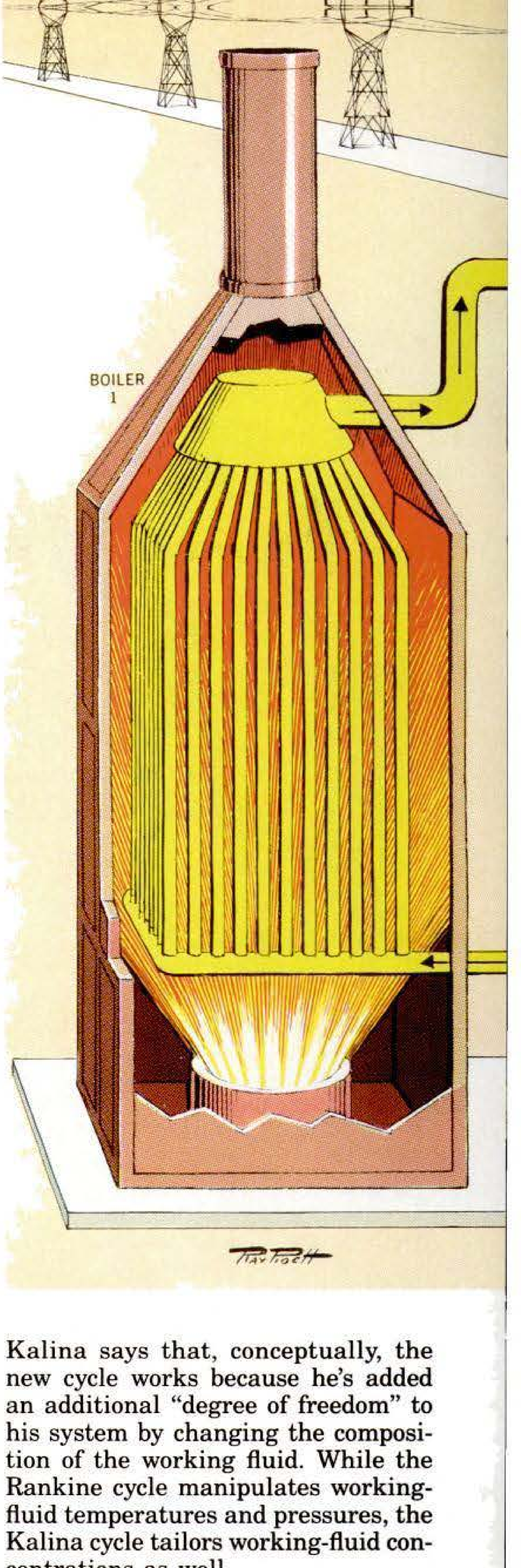

Rules for creative thinking

When Alexander Kalina was living in the Soviet Union, he heard of Myron Tribus, the eminent thermodynamicist, and made it a point to seek out translations of his papers or theories of systems design. One of those publications, Tribus relates, dealt with what he calls thermo-economics, "a technique by which cost information about plant components is developed simultaneously with the plant design. It can also give you insight into where it might be useful to do research, where the real payoff would be. Kalina was taken by this, and it helped him toward his own ideas.

"In the '60s," Kalina says, "I started thinking about a methodology for solving problems in systems design. And after a few inventions, I started forming some rules for creative thinking, though I never seriously thought to publicize them. In fact, I don't know if they are good or bad, only that they work for me.

"Step one is to formulate the ideal solution to your problem. At this point, forget about whether it's possible or not. When I was developing the [Kalina] cycle, I said to myself: For best operation at the boiler, I need a low-temperature boiling working fluid. That way, at a given temperature, I get the highest pressure possible. Likewise, at the condenser, I need a high-temperature boiling fluid. In that case, I get the lowest pressure possible for a given temperature.

"Step two," he continues, "is to identify the barriers that lie between you and your shining goal. Here you have to be absolutely fearless... you cannot be stopped by anything.

"Step three," Kalina says, "is when you ask, What is the heart of the problem? Once you have that, all else is a chain of technicalities. A related question is, Under what conditions does the problem cease to exist? This step is very time consuming. So there's always a big temptation to cut corners, but you pay for it in the end.

"To make the third step tractable," Kalina continues, "I use the method of division. Let's say you're going on vacation and you want to protect your house, so you decide to get a watchdog. But then you realize there'll be no one to feed him, so you decide to get a [intruder] sensor, a powerful tape recorder, and a tape of a barking dog. The point is, most of the time, you don't need the dog, you only need his bark."

PHOTO BY GREG SHARKO

When Kalina arrived in the United States, he visited Tribus, and the pair soon became friends. "The successful inventor seems to oscillate between being highly analytical and being very creative," says Tribus. "Thermoeconomic concepts can help you with the analysis, but not with creativity. Look, as far as Kalina's invention goes, it was all there for me to see as well as for him. But I couldn't see it. People looked around for different working fluids, but they didn't look around for the idea that you could have different fluids at different parts of the cycle."

Says Kalina: "It's kind of illogical to vaporize your working fluid and then condense it so you can vaporize it again, so you can condense it once more. That's the logic of my boy when he was three years old. I asked him why he broke his toy. He told me, 'so I can put it back together.' That kind of thinking led me to what turned out to be the heart of the problem."—S. A.

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maximizes the working fluid's *exergy*, the energy in the fluid that's available to do useful work."

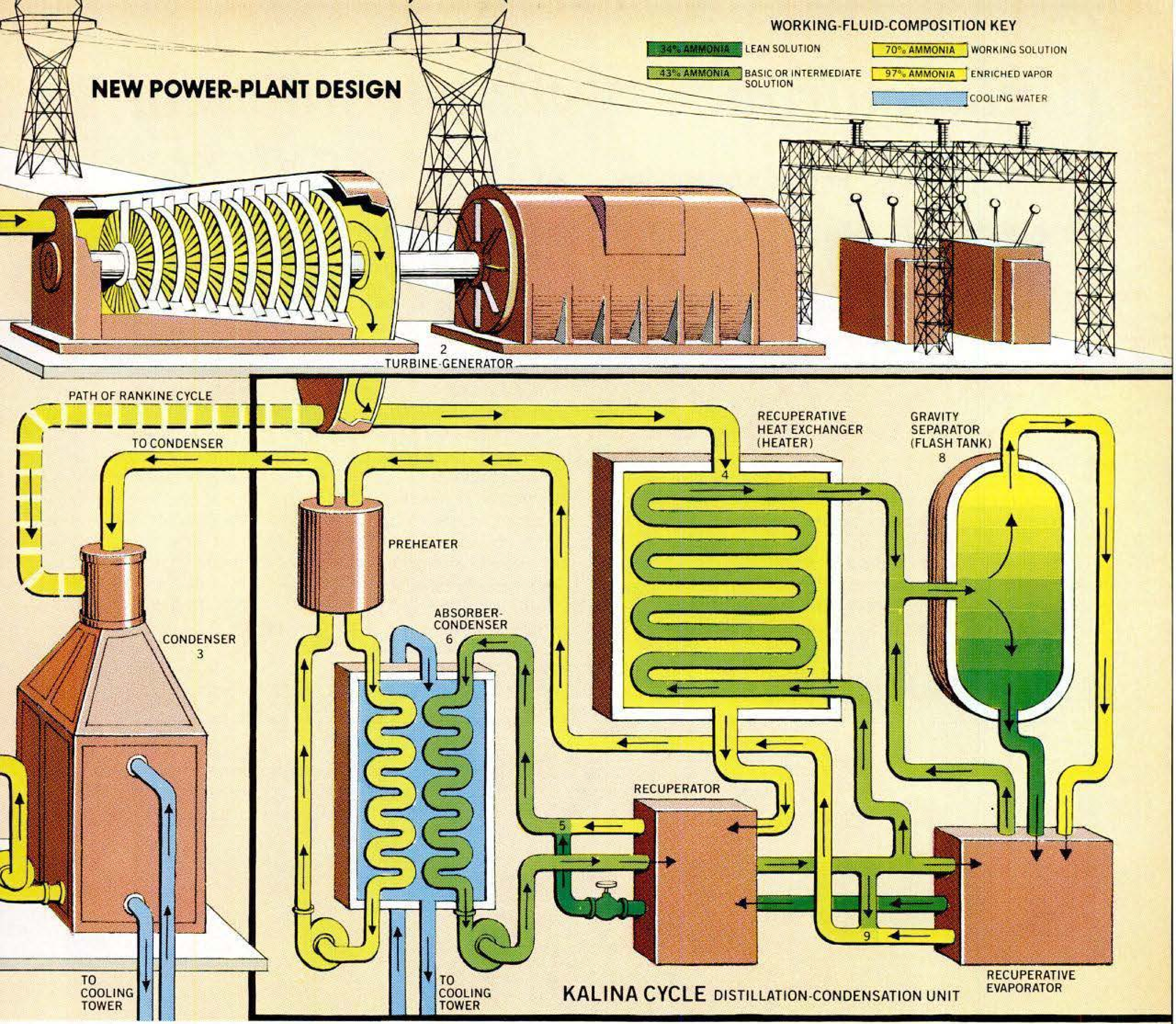
Though it's an old technique, the concept of a dual-component working fluid went unexploited because of one major drawback: Nobody figured out how to fully condense the fluid at normal heat rejection temperatures for recycling; that is, the mixture remains in a partial vapor state at 70 degrees F.

Kalina's solution is to change the concentration of the working fluid so it can be condensed. "Instead of a simple condenser," says Tribus, "Kalina uses a combination distillation, condensation, and mixing unit [see drawing]," which, he explains, allows him to break the working fluid into several streams with different ammonia concentrations. The incoming 70:30 mixture is diluted with water so it can be condensed. Part of the modified stream is then distilled to produce an enriched ammonia vapor, which, when added to yet another part of the modified stream, reconstitutes the 70:30 working fluid.

All the plumbing and mixing might seem like a lot of extra rigmarole, but it does the job—on paper, at least. Kalina says that, conceptually, the new cycle works because he's added an additional "degree of freedom" to his system by changing the composition of the working fluid. While the Rankine cycle manipulates working-fluid temperatures and pressures, the Kalina cycle tailors working-fluid concentrations as well.

"The Kalina cycle doesn't really exist," Kalina says with a Cheshire Cat smile. "It's really a general technology with several variants for different heat sources. In fact, there's no reason why I couldn't use a three- or four-part working fluid, even though you do start to get diminishing returns. That's what I'm working on now. I feel like a newcomer to a beautiful meadow with all kinds of nice, fresh berries to pick. Right now, I'm just picking berries."

While Kalina ponders newer schemes for even more efficient cycles,


NEW POWER-PLANT DESIGN
WORKING-FLUID-COMPOSITION KEY
34% AMMONIA LEAN SOLUTION
43% AMMONIA BASIC OR INTERMEDIATE SOLUTION
70% AMMONIA WORKING SOLUTION
97% AMMONIA ENRICHED VAPOR
COOLING WATER
2
TURBINE-GENERATOR
PATH OF RANKINE CYCLE
TO CONDENSER
RECUPERATIVE HEAT EXCHANGER (HEATER)
4
GRAVITY SEPARATOR (FLASH TANK)
8
PREHEATER
CONDENSER
3
ABSORBER-CONDENSER
6
7
RECUPERATOR
5
9
TO COOLING TOWER
TO COOLING TOWER
KALINA CYCLE DISTILLATION-CONDENSATION UNIT
RECUPERATIVE EVAPORATOR

In a conventional Rankine cycle system, steam produced by boiling water (1) passes through a turbine-generator causing it to spin (2). Afterward, it is condensed (3) and returned to the boiler (1) as liquid. In the Kalina cycle, a 70% ammonia/30% water working fluid permits boiling at variable temperatures, which allows more work to be extracted from the fluid. As it exits the turbine (2), the vapor is cooled in a recuperative heat exchanger (4) and then is mixed with a water-rich "lean" (34%) liquid (5). The resulting "intermediate" solution can be condensed (6), whereas the 70:30 fluid could not at this temperature. The pressurized condensate is then piped to the heater, where it cools the turbine exhaust (7). This now-hot, intermediate liquid is then separated by a gravity separator, or flash tank, (8) into two streams: a low-pressure, ammonia-rich (97%) vapor and the lean solution. The 70:30 working fluid is then reconstituted by mixing the ammonia-rich vapor and the intermediate solution (9).

power-generation experts are buckling down to evaluate whether Kalina's basic theory holds up in practice. Despite his claim that "in all of the system, there is no process or design technique that has not been successfully used, or tested hundreds of times in other technologies," experts indicate that there may be roadblocks to further development: higher-than-estimated capital costs, problems with equipment durability, safety problems from leaking ammonia (though industry has worked with it for years), and the possible dissociation of ammonia at high temperatures and pressures.

About the last concern, Kalina points to tests he's sponsored in which ammonia was exposed to conditions similar to those in the power plant. They indicated that there would be very little dissociation.

"We've all agreed with his general thermodynamic conclusions, but there's a distinct possibility that the increased efficiency may not pay for the capital costs," says Mike Gluckman, technical director for engineering and economic evaluation at the Electric Power Research Institute in Palo Alto, Calif. EPRI is conducting paper studies on the benefits of Kalina cycles installed in a gas-turbine bottoming cycle and in a 260-megawatt oil-fired turbine-generator.

"Most utility people with whom I've spoken are enthusiastic about the possibilities offered by the Kalina cycle," comments Bert Louks, project manager for the EPRI studies. "Right now, they're waiting to see if the prototypes work. If they do work, there will be a huge increase in interest. Still, with the kinds of investments involved in a full-size power plant, you can expect that utilities will want to see a 100-megawatt plant in operation before they enter into a venture." PS

Build your pick of nine winners of the 10th annual PS/APA contest: prize panel projects

By AL LEES

POPULAR SCIENCE readers are the source of the plans for these nine clever projects you can easily duplicate in your own shop. Most of them were built of ordinary plywood, available at any lumberyard. (Only the play castle, opposite page, made use of one of the newer structural panels—in this case ¾-inch waferboard.)

Projects for the 10th annual design competition, cosponsored by PS and the American Plywood Assn. (APA), could have been built of any structural panel: plywood, waferboard, particleboard, or a combination of several. There were nine prizes—a grand prize, special merit award, and honorable mention in each of three categories, based on the amount of panel material used: a half sheet (most lumberyards sell four-by-four-foot panels, and some will even rip a four-by-eight sheet lengthwise for you), full sheet, or multiple sheets (ranging from 1½ to six panels).

Ten years ago, the competition was simpler: Only projects built from a single four-by-eight sheet of plywood qualified, and you had to use as much of the sheet as possible, designing the parts so they could be nested for minimum waste. Over the years, eligibility has been broadened to include all structural panels and to let entrants

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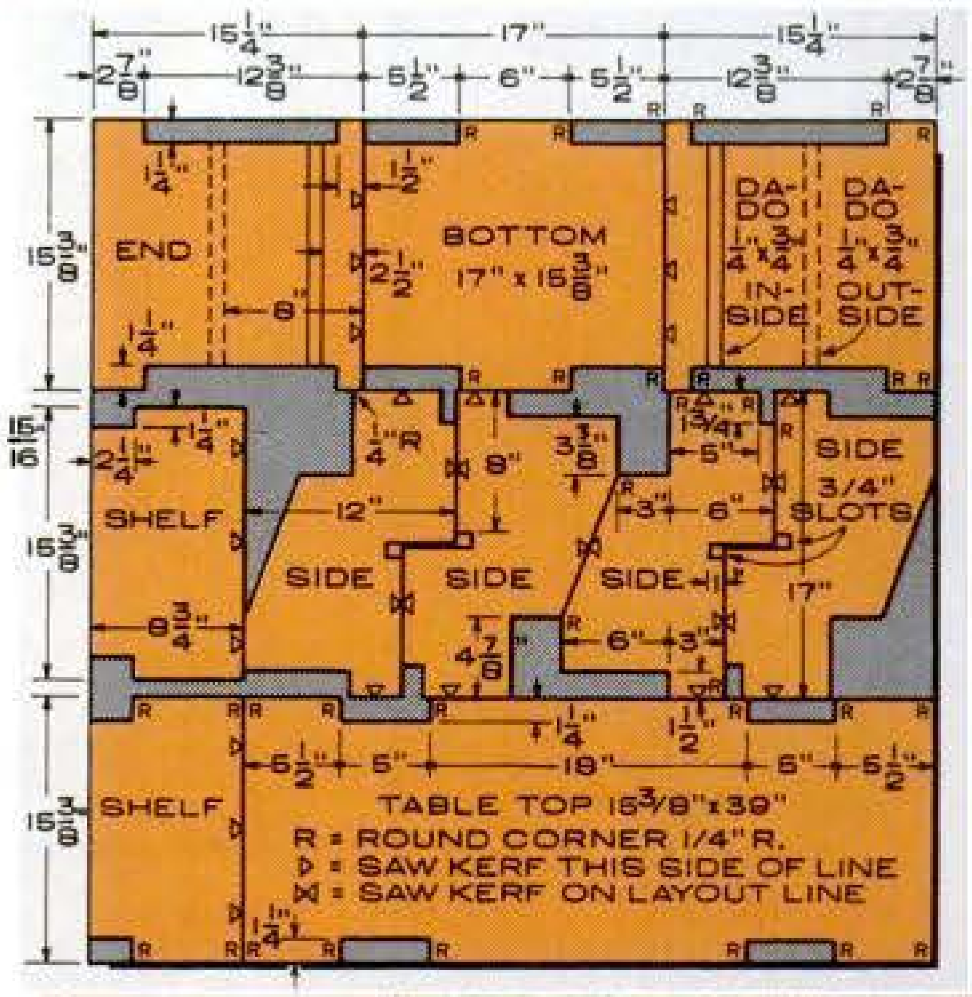
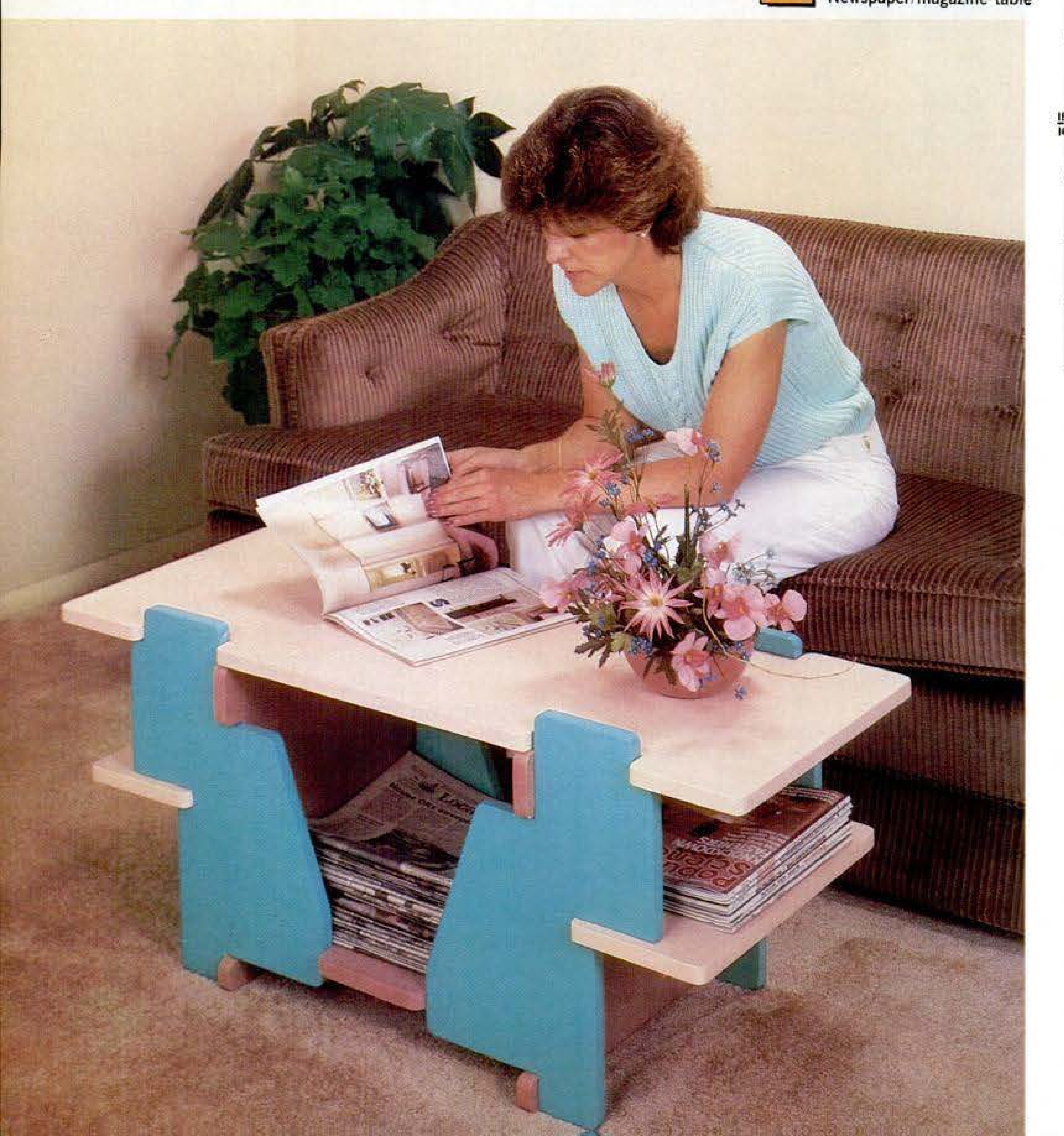
$1,250 GRAND PRIZES

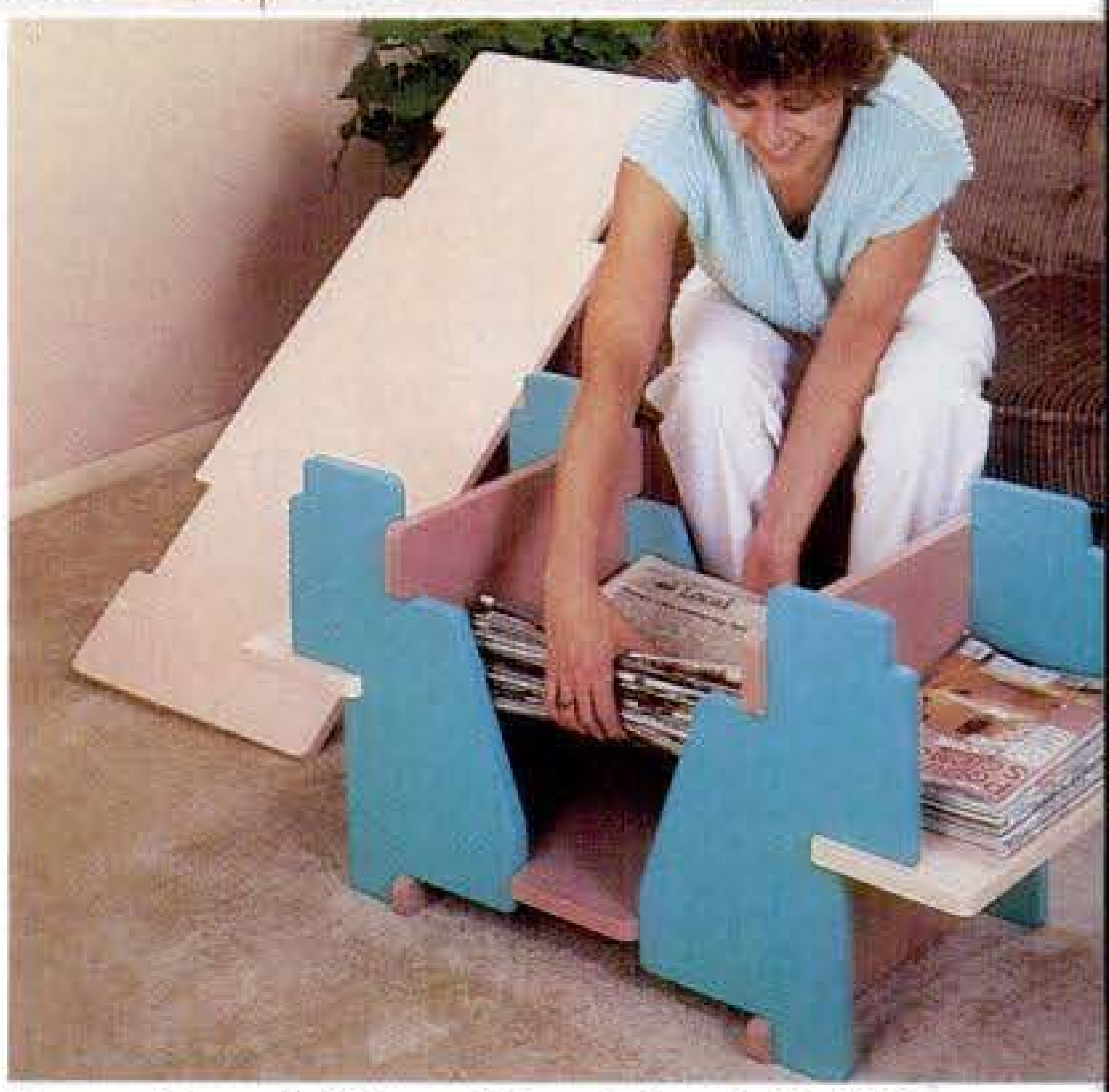
CATEGORY: ½ PANEL

3/4"

DAVID DEAR
Old Greenwich, Conn.
Newspaper/magazine table





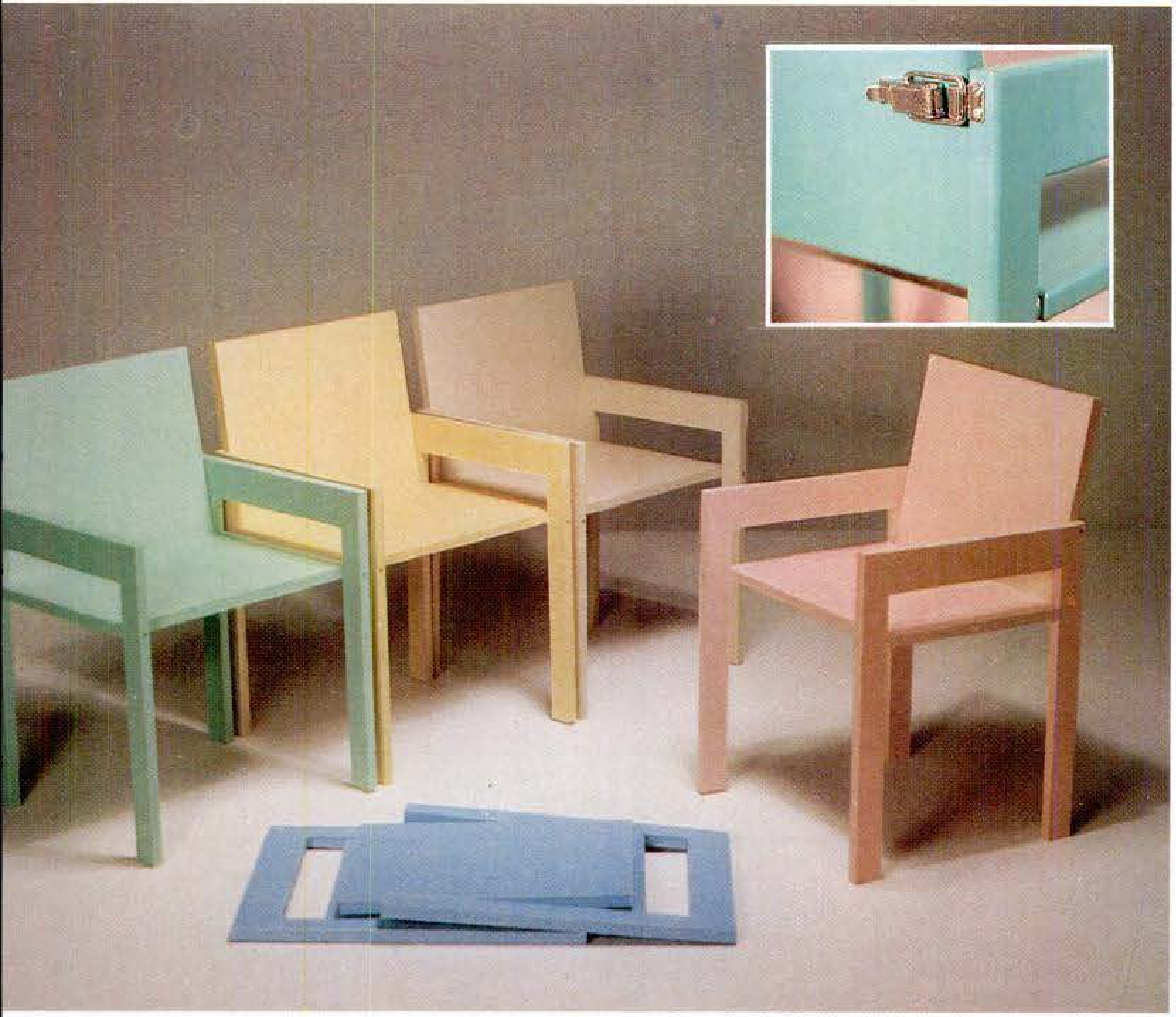


Functional Memphis: The label has nothing to do with Tennessee—it designates an Italian design group (see text) whose influence is felt in this table. The center compartment stores newspapers. The top lifts off, and the stack lifts out for bundling.

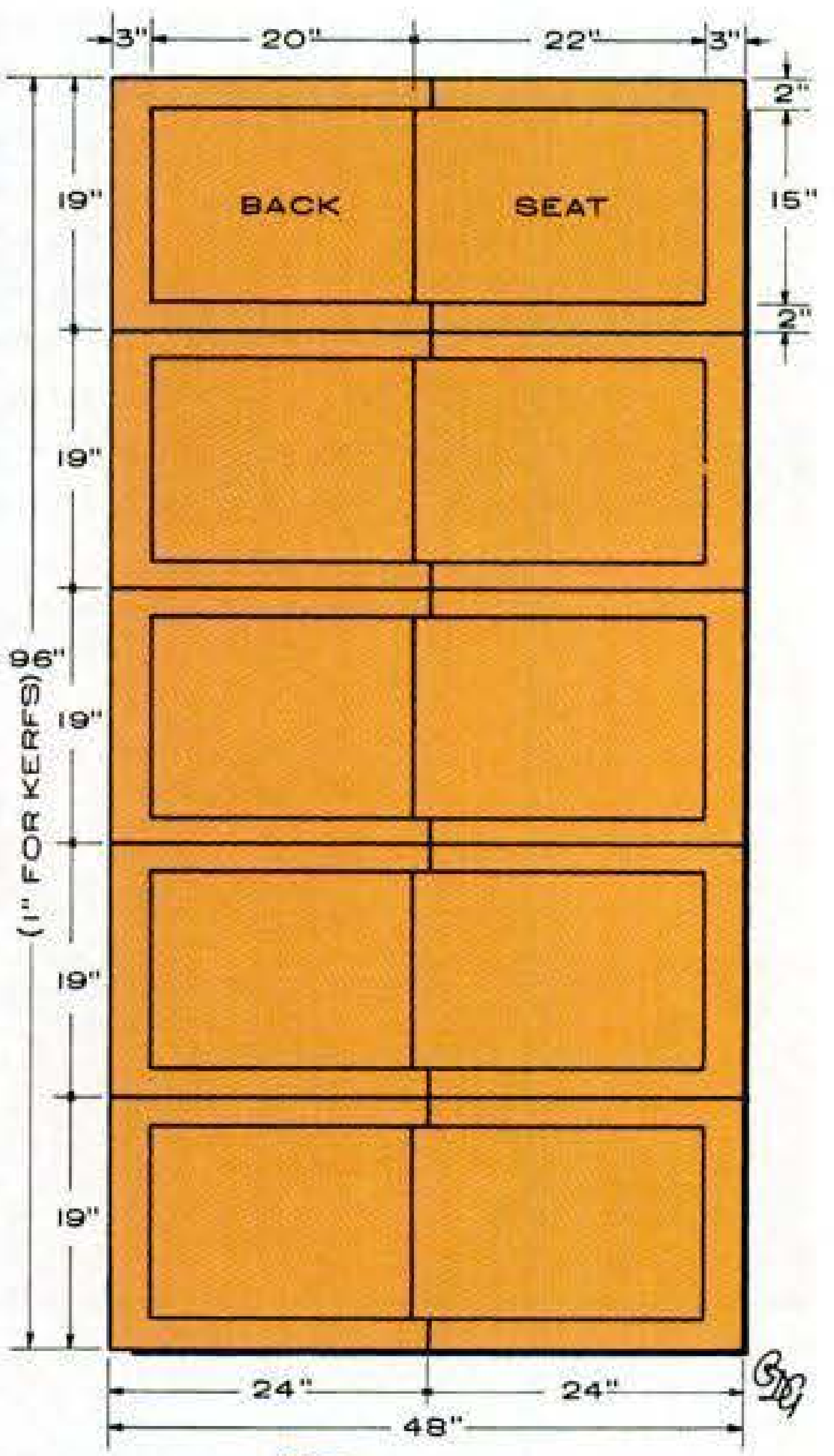
CATEGORY: SINGLE PANEL

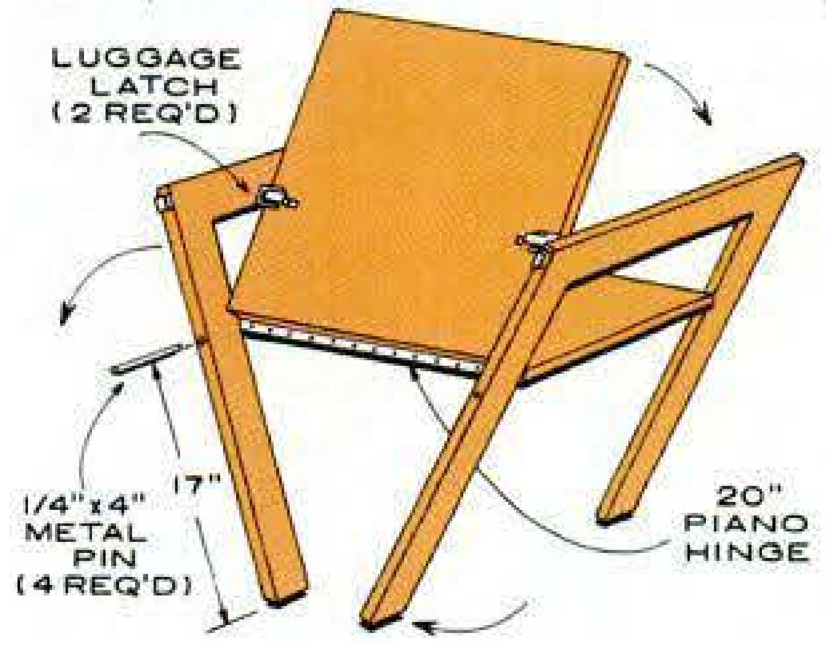
1"

CARSON AHLMAN
Oradell, N.J.
Five folding chairs



PHOTOS BY CARSON AHLMAN





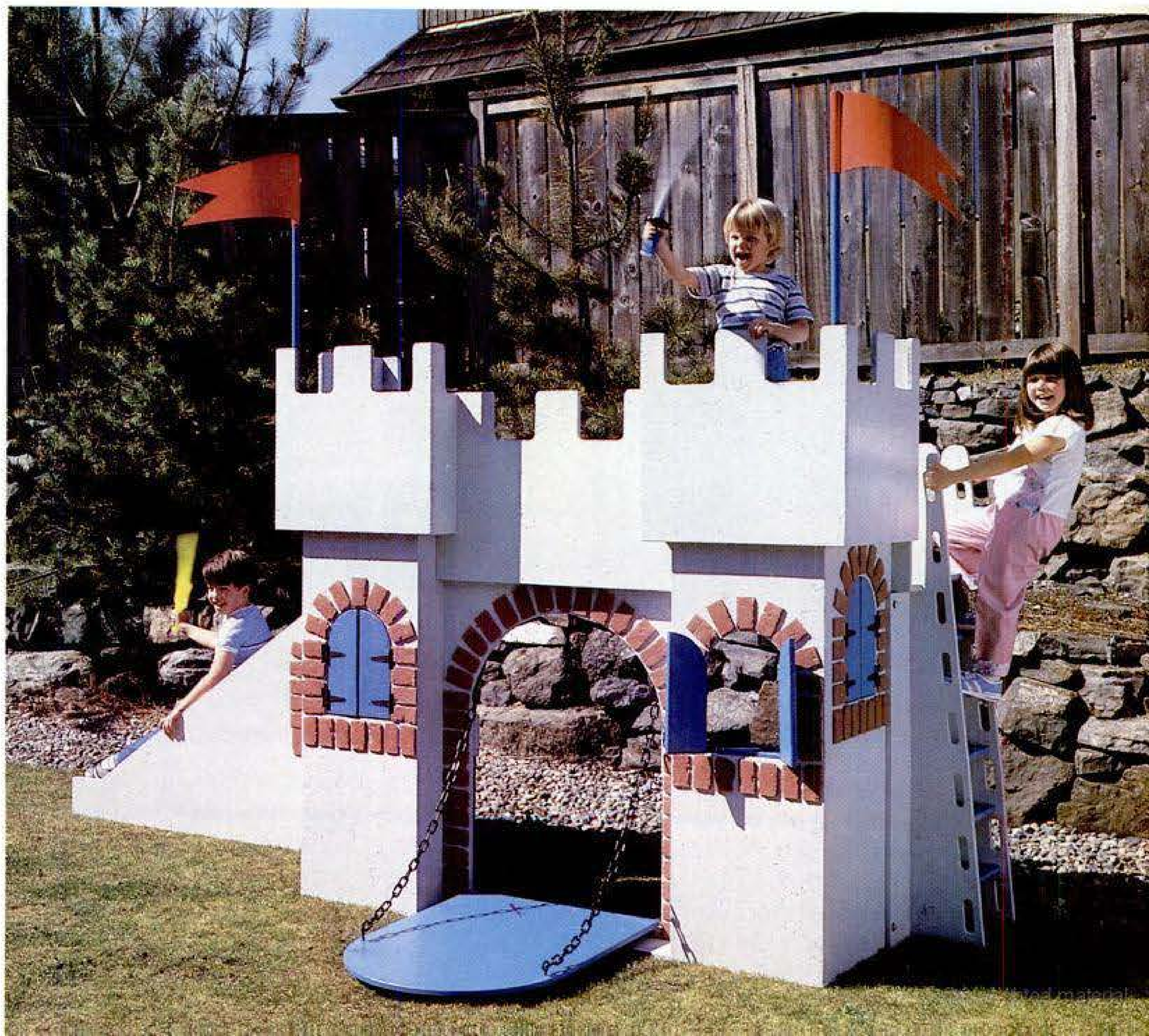
Five armchairs from one 4-by-8-ft. sheet of 1-in.-thick A-B plywood? It hardly seems possible until you check the no-waste cutting diagram above right. The four parts of each chair pivot and hinge together to fold flat, as shown in the drawing. Designer Ahlman painted each a different color.

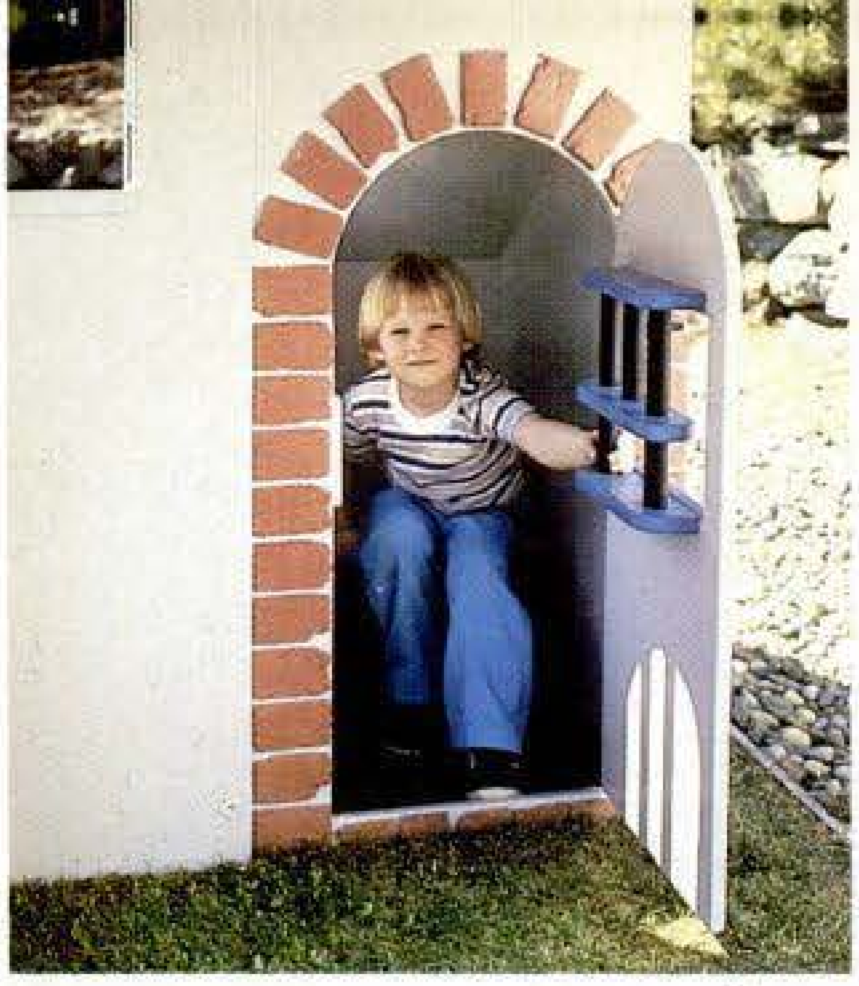
MULTI-PANEL CATEGORY:

3/4" 3/4" 3/4"
3/4" 3/4"

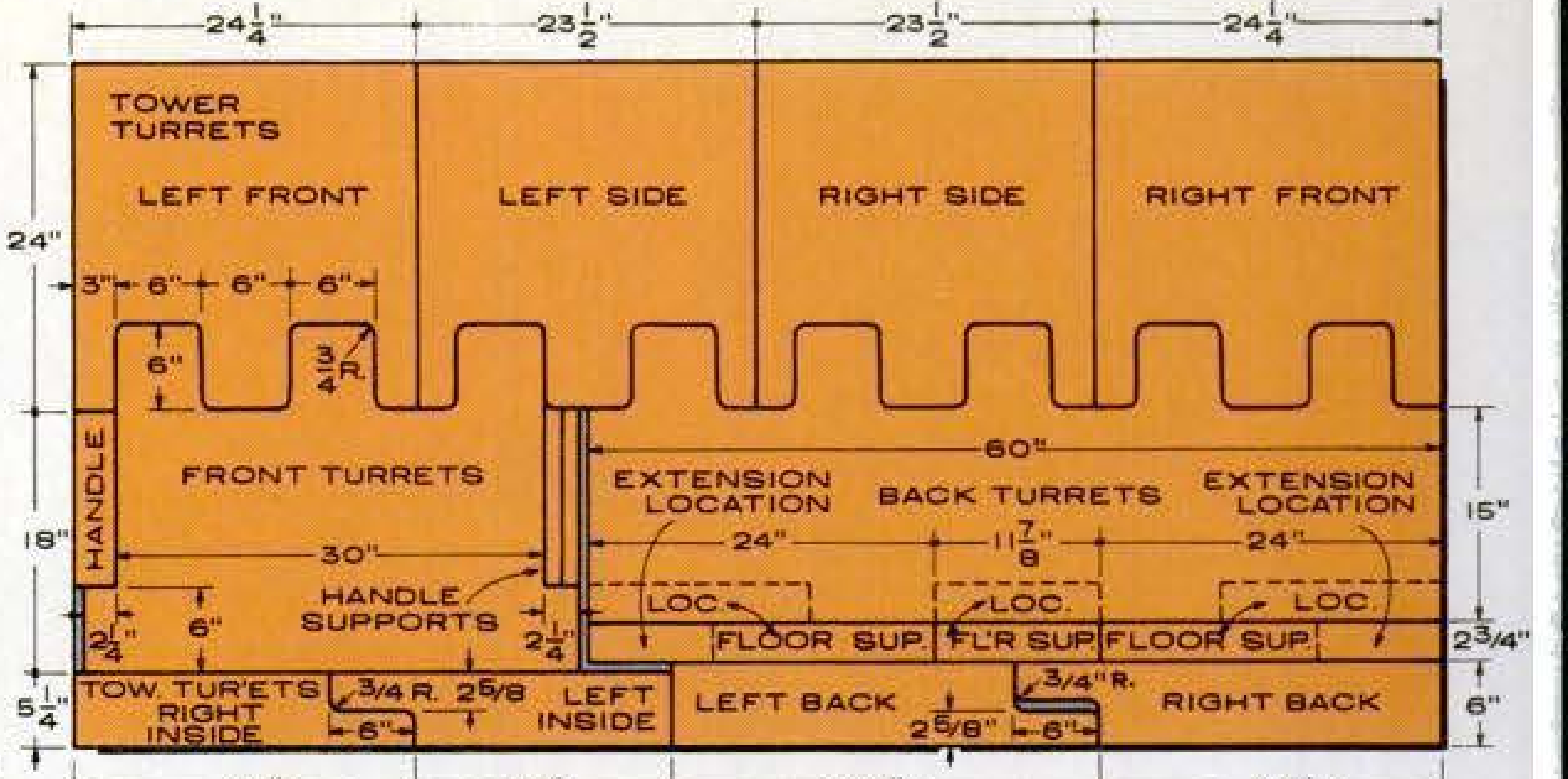
JOHN UNDERBRINK
Kirkland, Wash.
Play castle

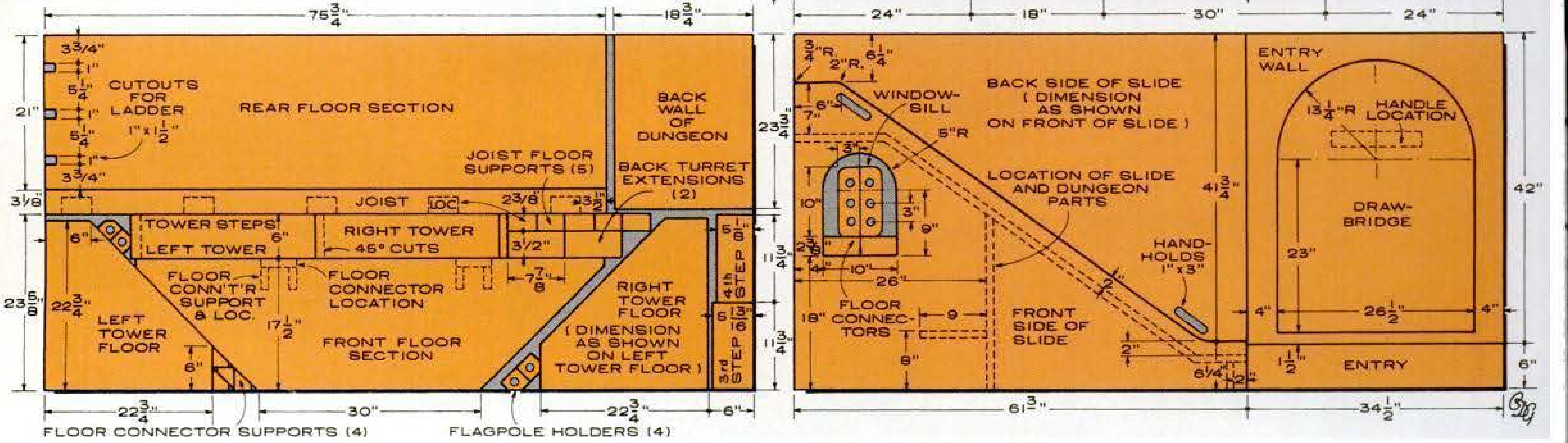
Two waferboard panels, when painted, give a masonry-like texture to the turreted walls of this castle. The parts nest for compact indoor storage (below).





Kids delight in the details of the play castle (shown in full on previous page), including this dungeon tucked under the slide, complete with a barred window in its door. Access to the slide is by a ladder at the opposite end: A child scales the wall, crosses the ramparts, and zips down the slide. Arches are outlined in veneer brick.



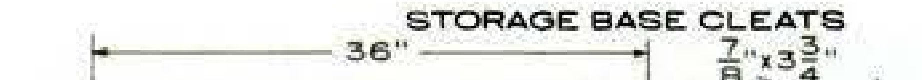


$500 SPECIAL MERIT AWARDS

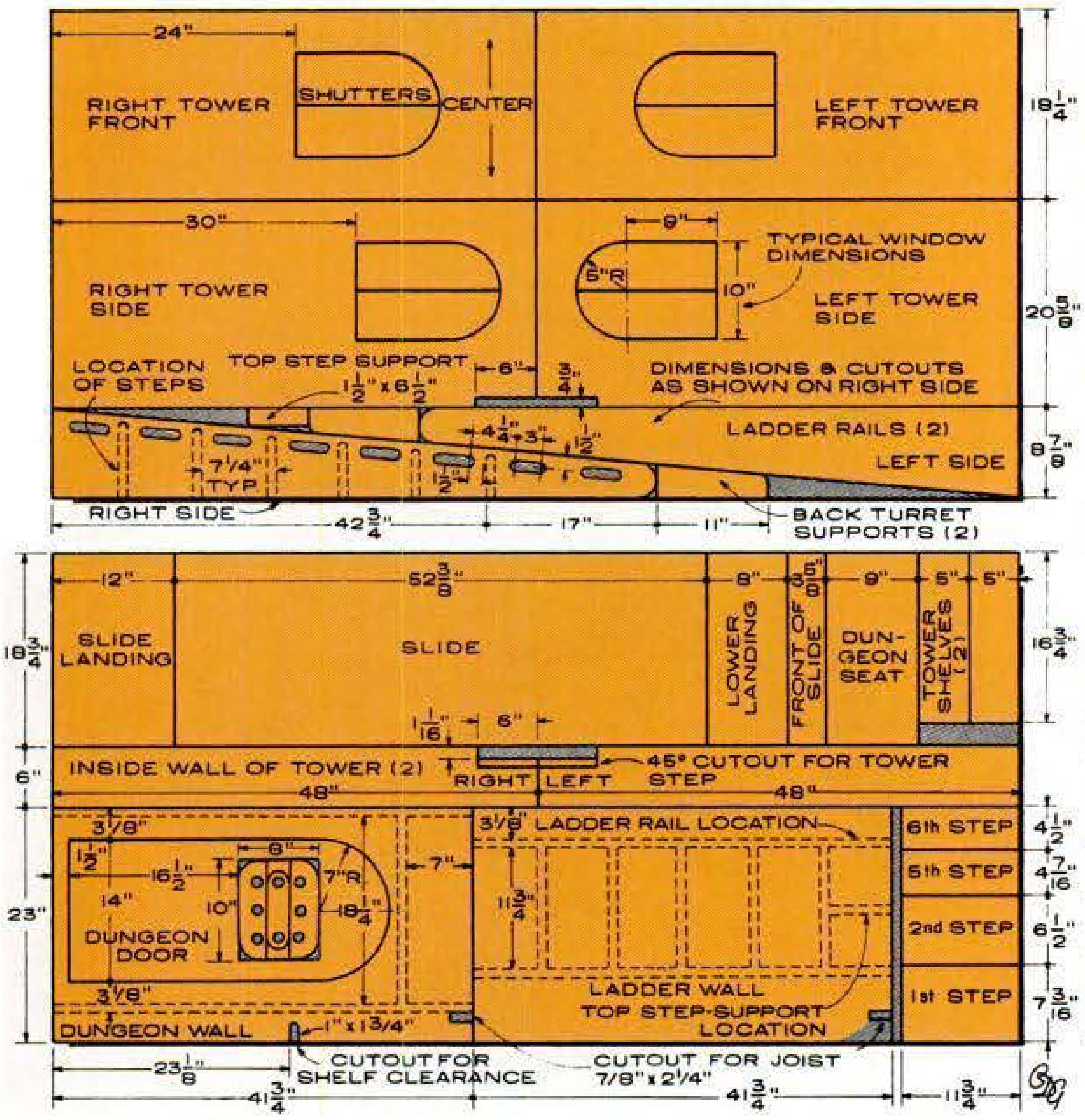
CATEGORY: ½ PANEL

3/8

JOHN RITSON
St. Augustine, Fla.
Child's easel bench



You'll keep any budding artist busy with this versatile drawing bench—all parts cut from a half sheet of ⅜-in. ply. You can surface the easel-desk panel with chalkboard paint for maximum use. The panel pivots from an easel position (photo, right) to a flat surface (above) that's ideal for coloring books. Books store in the rear pocket.



choose the amount of material appropriate to the size of project they wished to design. But the efficient utilization of the chosen panel or panels has remained a prime requirement, challenging not only an entrant's design ingenuity but his or her problem-solving abilities, as well.

As you leaf through this project portfolio, you'll note a small panel symbol next to the name and address of each winner. This symbol tells you how much panel of what thickness is needed to build the project. As I've said, the nine winners weren't adventurous in their panel selection. This year, all chose to work with plywood. You'll note that two of the panel symbols for the play castle are shaded to indicate the only waferboard called for; no winning entrant used particleboard.

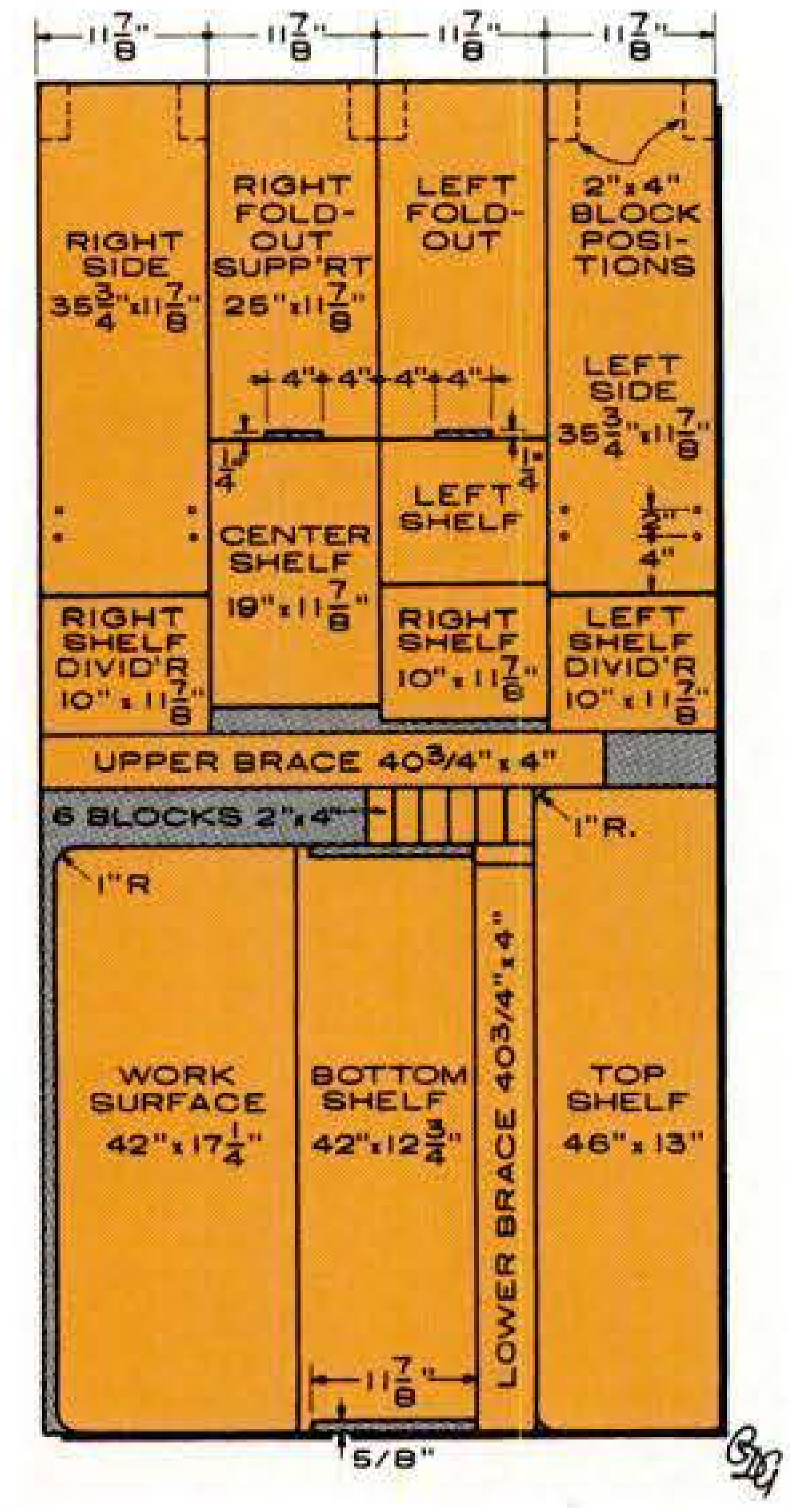
In rebuilding all but one of these projects for photographing, APA elected to use medium-density overlaid (MDO) plywood, to simplify painting. MDO is softwood ply that's coated on both sides with a baked-on dark resin that obscures the grain and provides supersmooth faces. If you prefer a finish that exposes the natural grain pattern, you'll want to choose a good sanded grade plywood—A-C or better. The A indicates a top-quality face veneer; the C means that a less-perfect veneer—probably with knots and patches—was used for the back face. Because none of this year's projects is intended for prolonged weather exposure, interior grade panels will suffice. (These

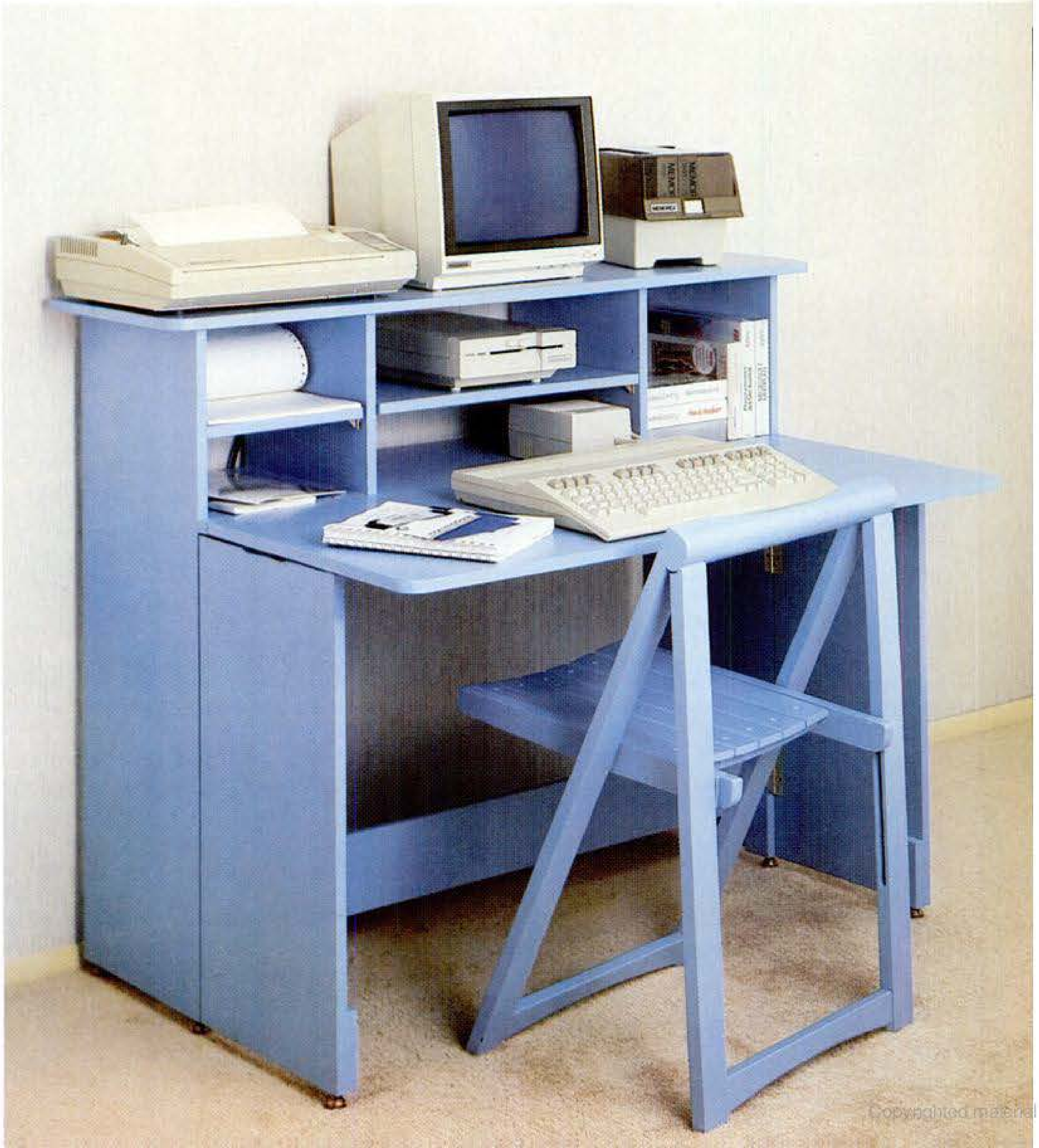
Continued

CATEGORY: SINGLE PANEL

5/8"

STEVEN C. MARRIOTT
Bettendorf, Iowa
Drop-leaf computer desk


11 7/8"
11 7/8"
11 7/8"
11 7/8"
RIGHT SIDE 35 3/4" x 11 7/8"
RIGHT FOLD-OUT SUPP'RT 25" x 11 7/8"
LEFT FOLD-OUT
2" x 4" BLOCK POSITIONS
4" 4" 4" 4"
LEFT SIDE 35 3/4" x 11 7/8"
1/4"
CENTER SHELF 19" x 11 7/8"
LEFT SHELF
4"
RIGHT SHELF DIVID'R 10" x 11 7/8"
RIGHT SHELF 10" x 11 7/8"
LEFT SHELF DIVID'R 10" x 11 7/8"
UPPER BRACE 40 3/4" x 4"
6 BLOCKS 2" x 4"
1"R.
1"R
WORK SURFACE 42" x 17 1/4"
BOTTOM SHELF 42" x 12 3/4"
LOWER BRACE 40 3/4" x 4"
TOP SHELF 46" x 13"
11 7/8"
5/8"



This compact computer desk is ideal for a room that's tight on floor space. When not in use, the keyboard slides back into its cubbyhole, the support doors fold in to close the cabinet, and the desk leaf drops down. The unit flattens so effectively against a wall that it can even be placed in a secondary traffic lane. It all comes out of a single sheet of ⅝-in. plywood, with minimal waste. An MDO-grade panel was used to simplify painting, and a folding chair was bought and painted to match.

panel types are usually less expensive than exterior ones.)

All nine of these projects are easy to duplicate. Three are so simple you won't find them listed in the APA order coupon on the last page of this portfolio. Because you only need the cutting layouts presented on these pages, APA decided not to prepare a plans sheet for them. Construction details for the other six projects are available in separate plans folders. You get a larger version of the cutting layouts shown here, plus detailed assembly sketches. Just fill out the coupon, indicating which plans you want, and mail it with proper remittance to APA's Tacoma address.

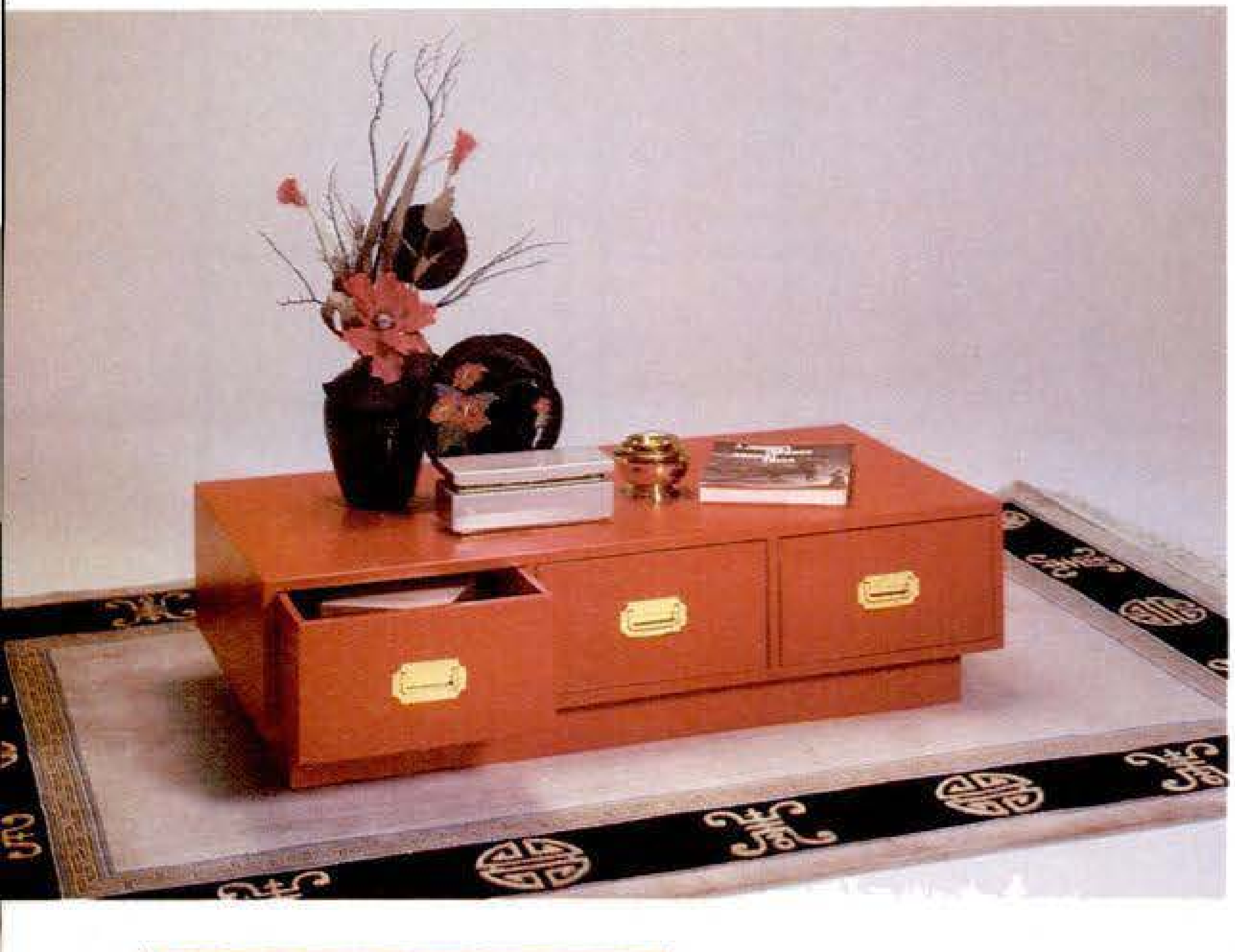
The first of the three complete-in-this issue projects is the newspaper-caddy cocktail table. Designer David Dear calls his project MANO (for magazine and newspaper organizer). As the photo shows, you dispose of your daily

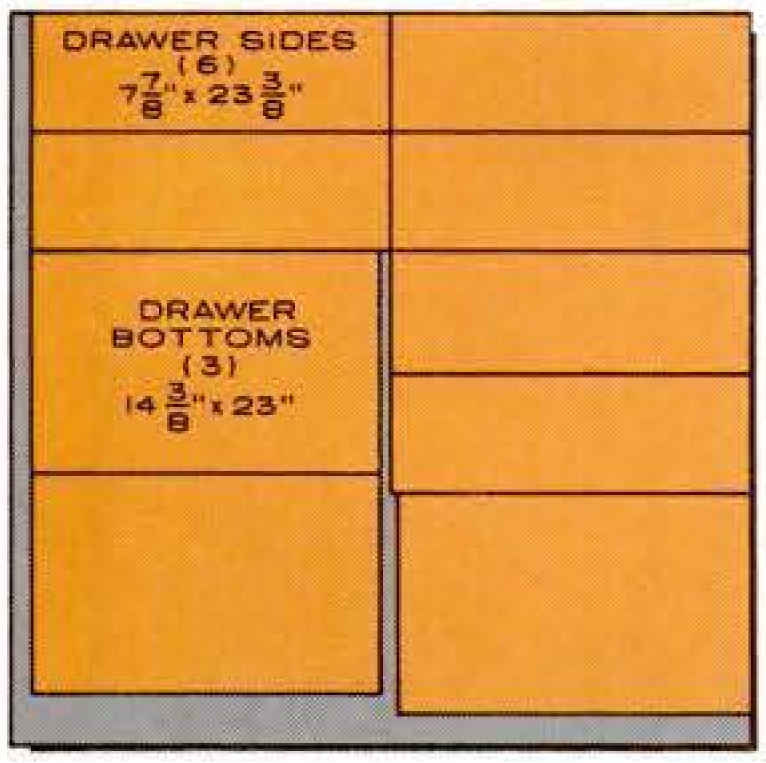
Continued

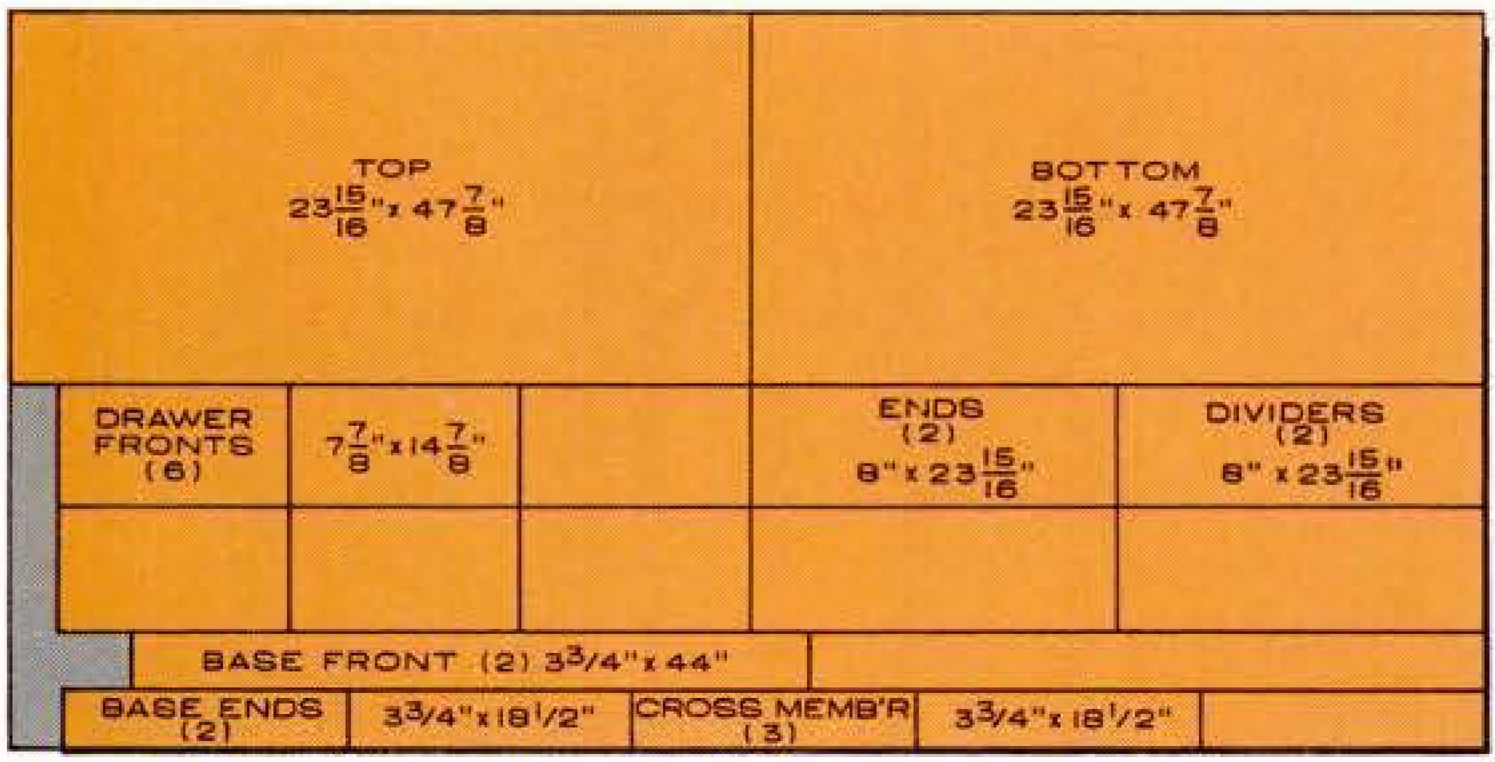
CATEGORY: MULTI-PANEL

3/4" 1/2"

ERLIN CLEMENT
Detroit, Mich.
Storage coffee table




DRAWER SIDES (6) 7 7/8"x23 3/8"
DRAWER BOTTOMS (3) 14 3/8"x23"



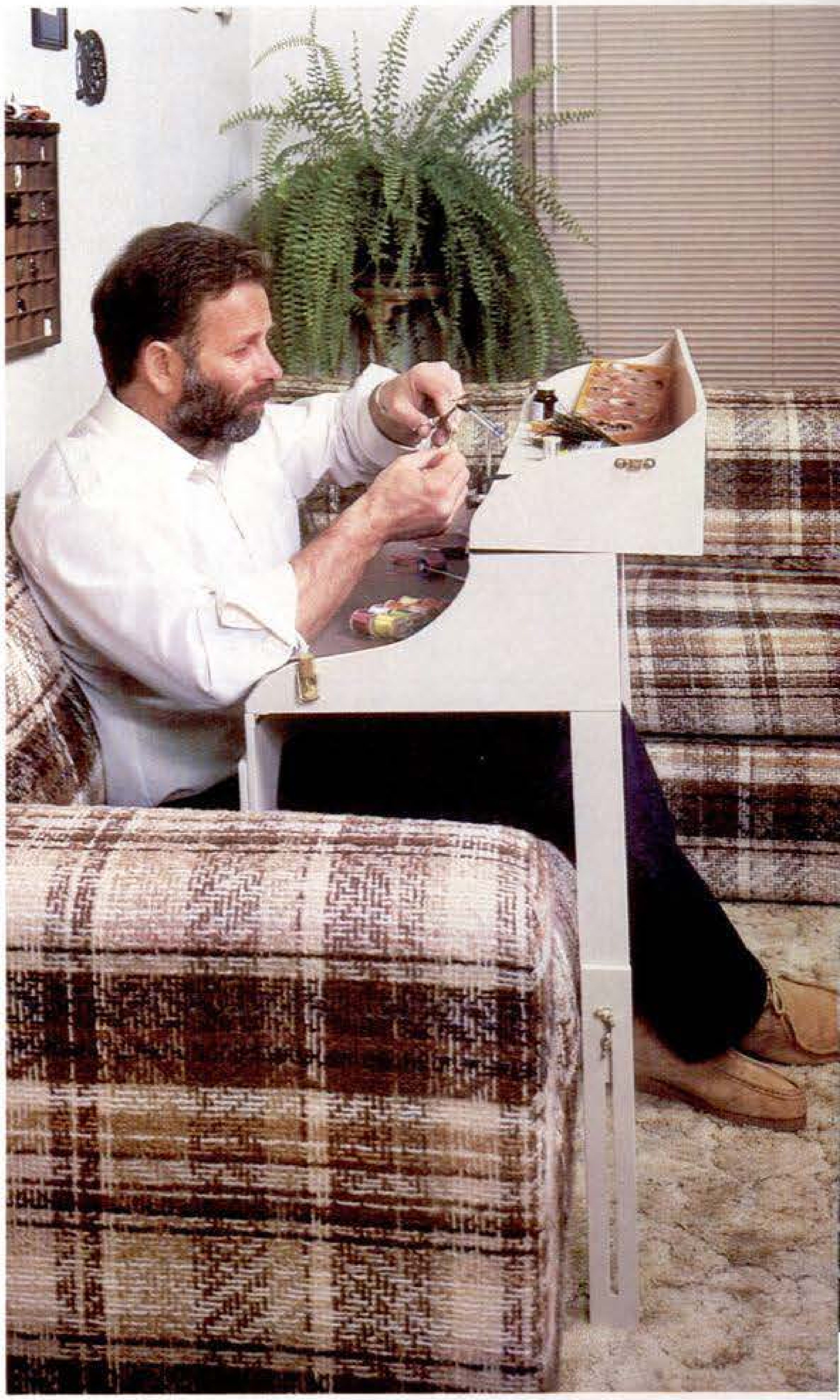
Three large storage drawers in this Oriental coffee table have handles on both ends to let them open to either side. This simplifies access, making them doubly useful. The handles also let you lift the unit. A sheet of ¾-in. ply yields all carcass parts plus six drawer fronts. The remaining drawer parts come from a half sheet of ½-in. ply.

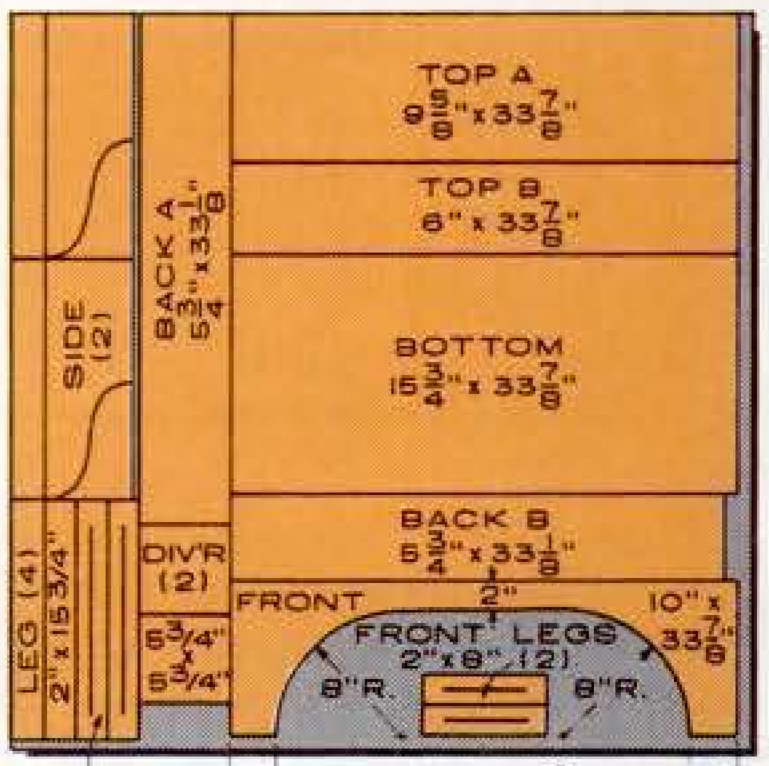
HONORABLE-MENTION AWARDS

CATEGORY: ½ PANEL

1/2"

J. P. KURTH
Sheridan, Wyo.
Sofa lap desk



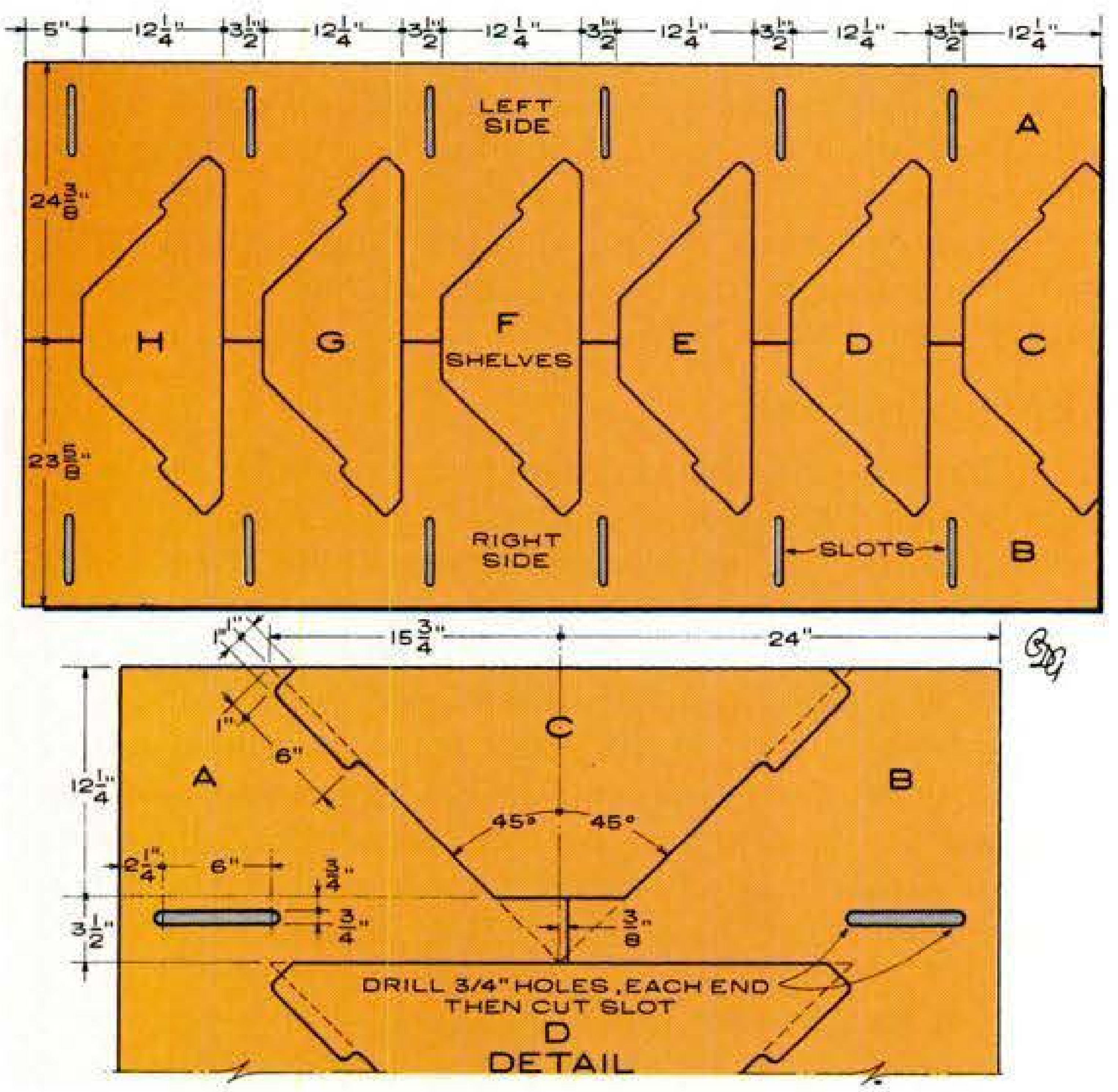


Many hand-active hobbies, such as fly-tying (above), wood carving, and stamp or coin collecting, don't require undivided attention, so they're pleasant to pursue while you're conversing with family or watching TV. This portable lap desk lets you take your hobby to a comfortable couch. It folds for carrying, and its floor legs adjust.

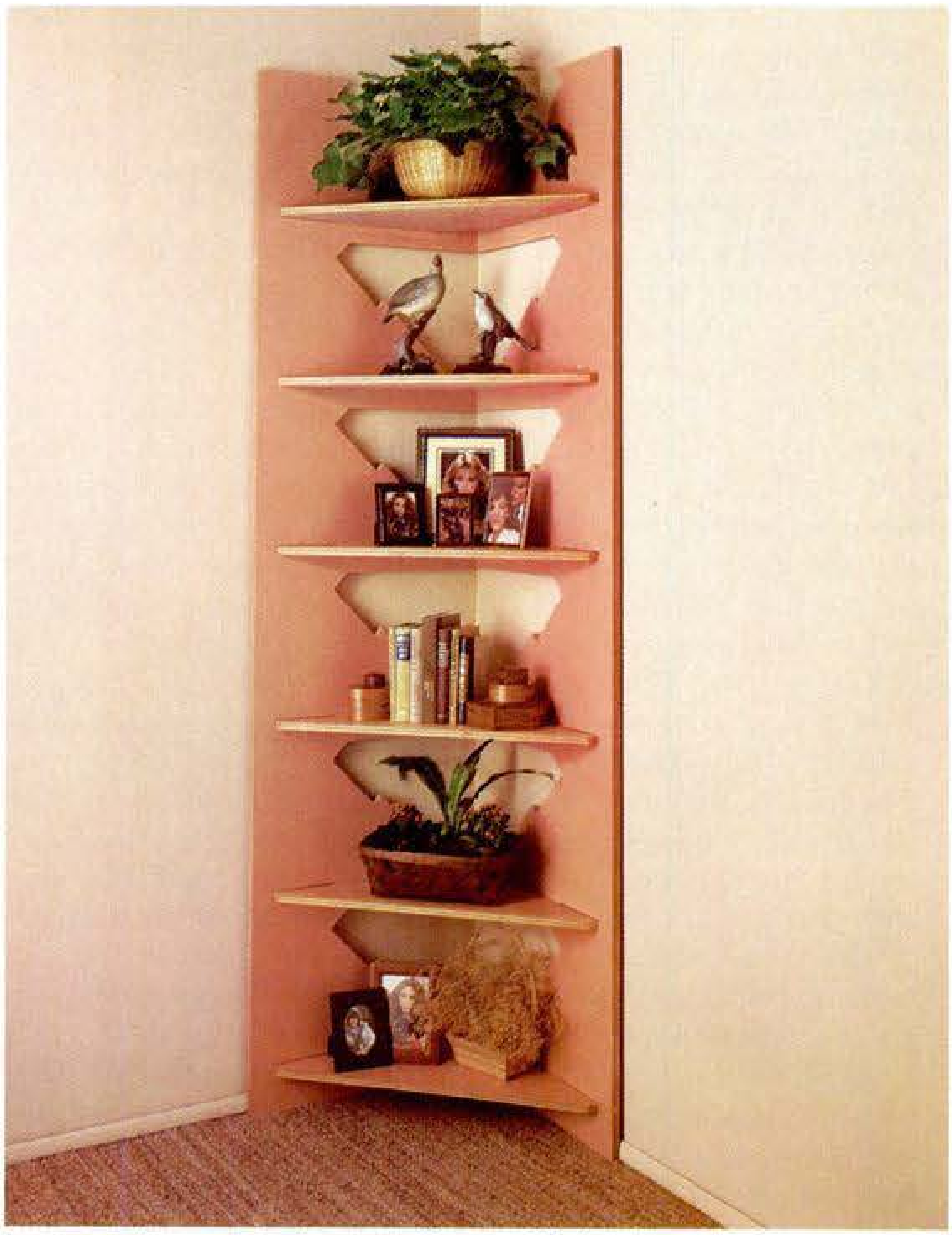
CATEGORY: SINGLE PANEL

3/4"

DONALD W. MacDONALD
San Francisco, Calif.
Corner shelves



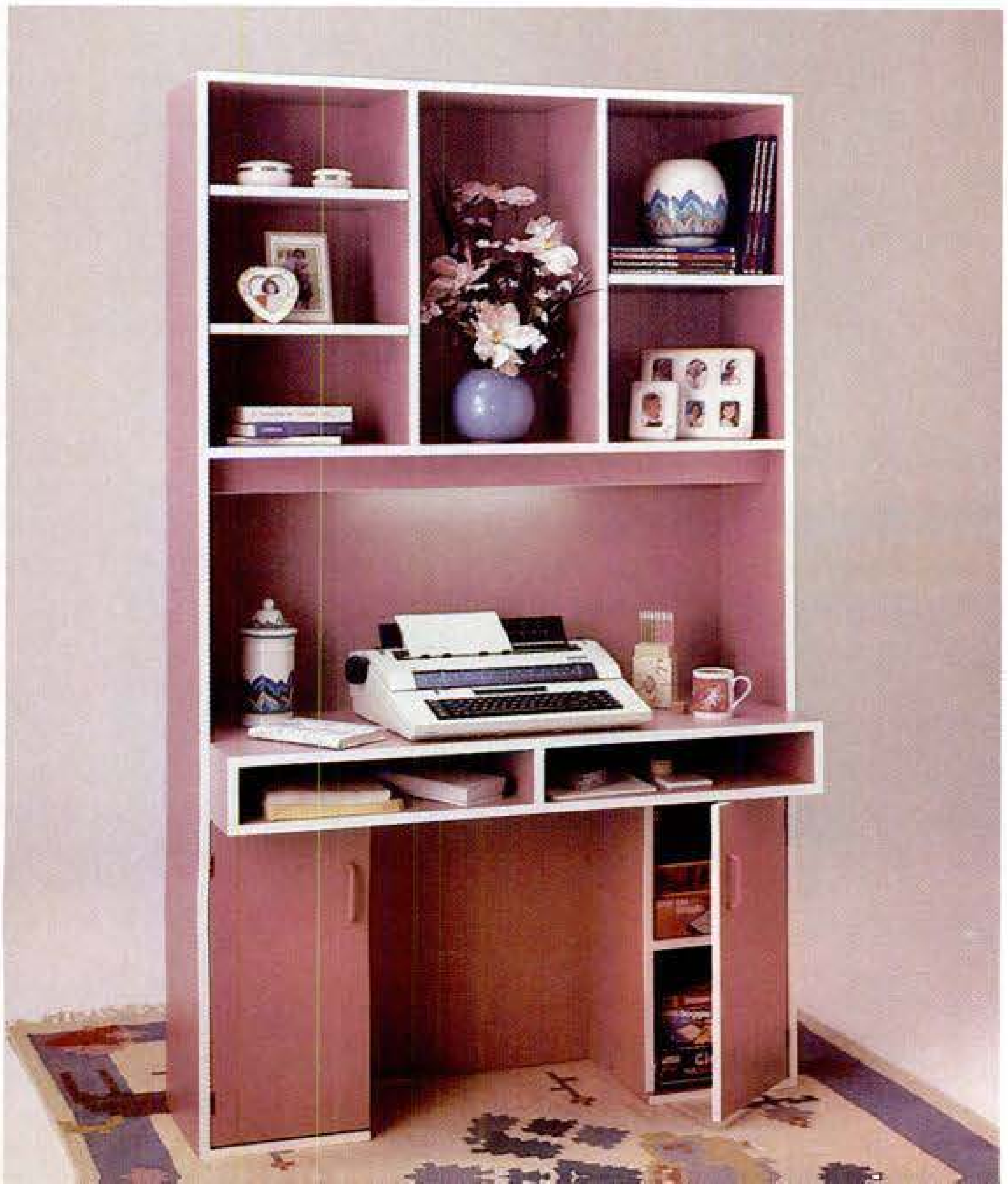
In this contest's history there's rarely been a project that used a single plywood sheet so simply, with as little waste. As the detail above shows, each shelf is centered on the panel; once all six are cut out, the remaining panel is sliced in half to form two uprights. Slots are cut to take edge tabs on the shelves, and all parts are glued together.

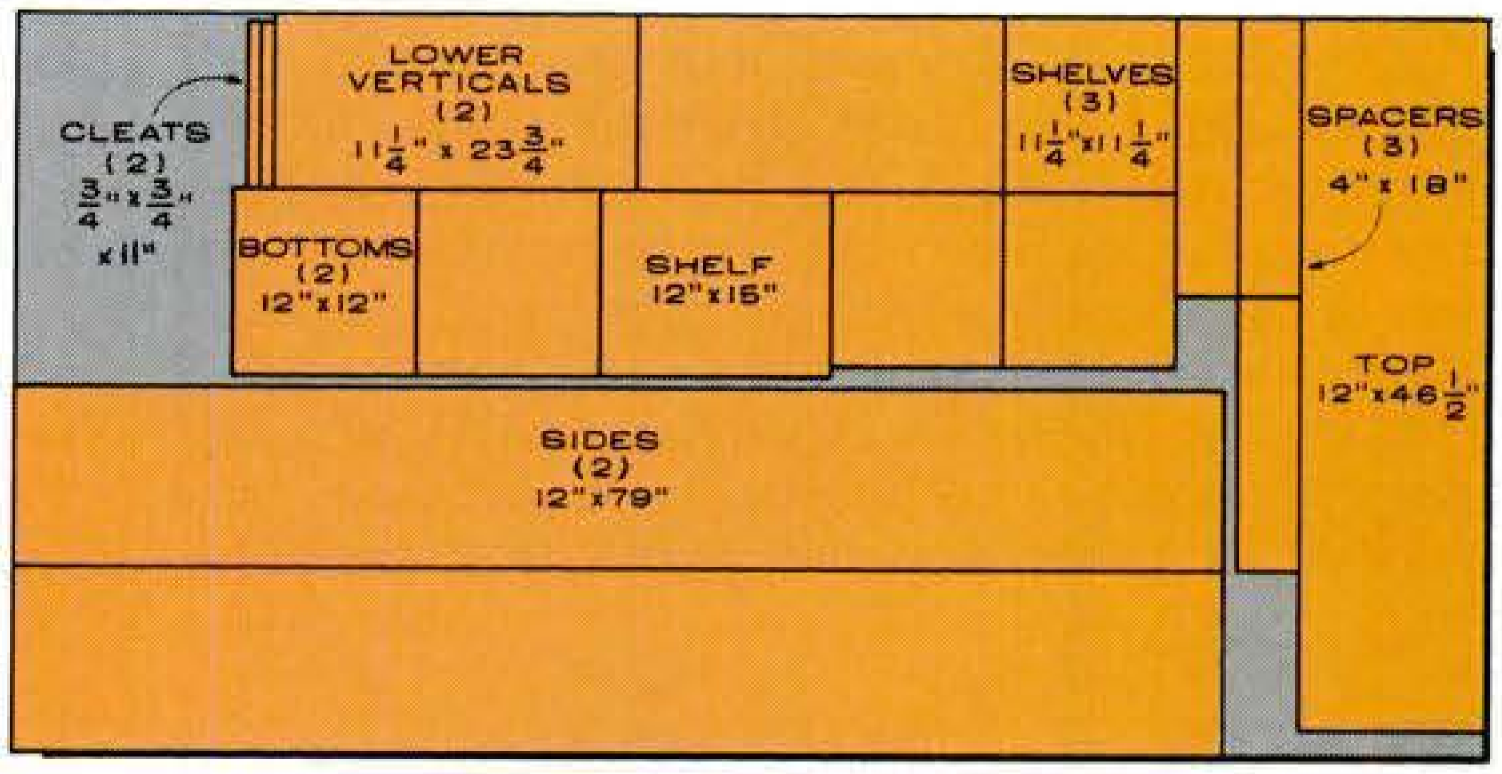


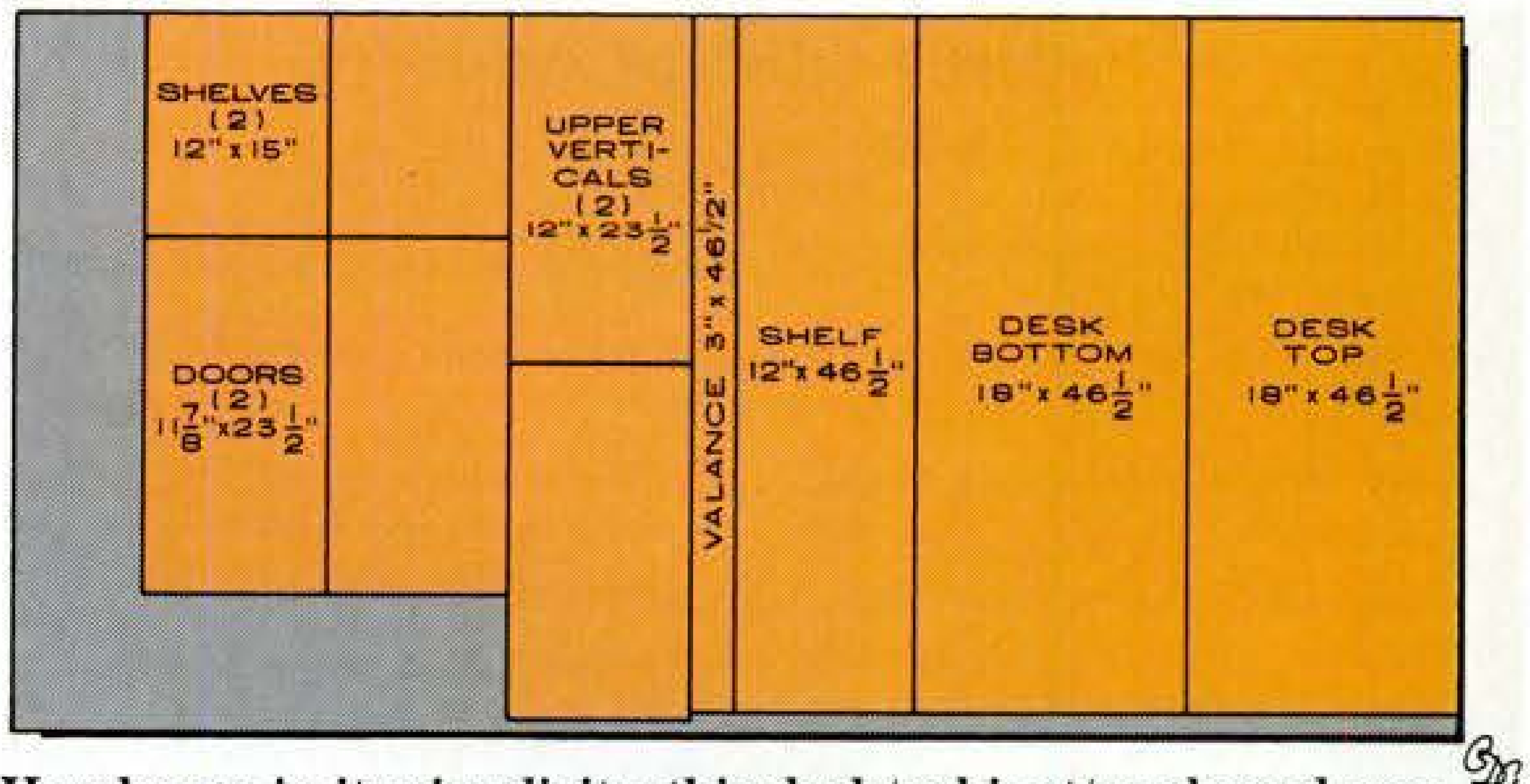
CATEGORY: MULTI-PANEL

3/4" 3/4"

RICHARD CRONENWETT
East Windsor, N.J.
Modular secretary




CLEATS (2) 3/4" x 3/4" x 11"
LOWER VERTICALS (2) 11 1/4" x 23 3/4"
SHELVES (3) 11 1/4" x 11 1/4"
SPACERS (3) 4" x 18"
BOTTOMS (2) 12" x 12"
SHELF 12" x 15"
TOP 12" x 46 1/2"
SIDES (2) 12" x 79"


SHELVES (2) 12" x 15"
UPPER VERTICALS (2) 12" x 23 1/2"
VALANCE 3" x 46 1/2"
DOORS (2) 11 7/8" x 23 1/2"
SHELF 12" x 46 1/2"
DESK BOTTOM 18" x 46 1/2"
DESK TOP 18" x 46 1/2"

Handsome in its simplicity, this desk/cabinet/cupboard combines practicality and attractive display. A fluorescent fixture behind the valance illuminates the work surface. For photography, a third, 3/8-in.-thick, panel of ply was nailed on back, but prefinished wall paneling or hardboard could be used. All other parts come from 3/4-in. ply.

paper by slipping it into the center section until the stack grows high enough for bundling. Then the table top lifts off for easy access. In addition, there are two end compartments scaled for stacks of magazines. And all this practical ingenuity in Memphis packaging! Memphis is the name of an Italian design group whose bizarre shapes and lively color combinations have added a controversial dimension to current furniture design. Memphis pieces aren't always noted for their functional quality, however, so I was impressed that MANO puts this design philosophy to so practical a purpose.

Dear suggests a trial-assembly before finishing; sand or file mating parts as needed for an accurate fit. Drill all clearance holes, countersinking for flathead screws. When assembly is complete, drill through these holes with a smaller bit to create pilot holes. Disassemble, labeling pieces so they'll go back together the same way (right side, left shelf, etc.), then paint all parts before reassembly. In keeping with the Memphis influence, we used three colors. Screw heads can be set flush and left exposed or can be sunk below the surface and capped with wood dough (with touch-up painting after the dough dries).

The second project that's simple enough to duplicate from the sketches supplied is Carson Ahlman's set of five folding chairs from a single panel of inch-thick plywood. Because both faces of all parts will be exposed, buy the best quality panel you can find. After marking the simple layout on the back face of your plywood, cut the sheet into five equal panels, then drill a hole at all four corners of the inner section of each panel—the section that will become the back and seat of each chair. These holes allow you to insert a sabre-saw blade to make the inner cuts.

Next, drill a ¼-inch-diameter hole centered on the edge of each leg, 17 inches from the bottom. These holes, four per chair, go all the way through each leg, and should be a drive fit for the four-inch-long metal dowel pins that will be tapped into them. Four mating holes, drilled in the edges of the seat panel, are two inches deep; these should be slightly larger in diameter so the pins will pivot.

After painting all parts, join the seat and back with a 20-inch continuous hinge. Drive the metal dowels (cut from a ¼-inch rod) through the legs to engage the seat, inserting a washer between the two parts at each pivot. Screw the brass luggage latches to back panel and leg units as shown in the inset photo.

Maryann Olson, my colleague at APA who has helped me with this annual judging in recent years, was as impressed as I with designer Ahlman's choice of colors for these chairs—and with the photo he submitted with his entry. So we decided not to rebuild and reshoot.

The last of the three projects for which no plans sheet will be sold is the corner shelf unit. You'll note from the cutting layout that the same pattern is repeated six times on the four-by-eight-foot panel. You'll need some skill with a sabre saw to get all the shelf pieces out of the panel. To cut the slots into which the shelf tabs fit, drill holes at each end, insert the sabre-saw blade, and cut between. You'll note from the photo that when we painted the parts (before assembly) we left all exposed edges natural. The edge plies become a design element; any voids are filled with wood dough and sanded smooth before edges are coated with a clear varnish.

That's all, folks

I'm particularly pleased that this year's portfolio of projects is such a handsome and useful one—because it's the last. APA and PS have decided to terminate their annual cosponsorship because it has achieved the goal set for it in 1976—demonstrating that handsome and useful projects for the home can be economically built from structural panels. Over the 10 years since, I've been able to select a great variety of well-designed projects, and even collected the first eight years of them into a hardcover book, *67 Prizewinning Plywood Projects,* still available from Popular Science Books, Dept. APA, Box 2018, Latham, N.Y. 12111 (for $27.95 plus $2.39 for shipping).

We felt that to continue the contest would risk repetition. Instead, PS in future issues will be devoting how-to pages to specially commissioned projects for the home. And, of course, any readers who design and build innovative projects for their own use are still invited to submit them for publication at regular PS rates.

Meanwhile, congratulations to the final nine winners. Those in the first two categories have received checks in the indicated amounts; our three honorable-mention winners have been sent libraries of selected PS how-to books.

Only one of this year's winners has won previously. Last year John Underbrink surprised us by taking prizes in two categories—half-panel and single-panel. This year he adds the Triple Crown by winning the multi-panel category. John's an industrial designer, and reports that the complexities of designing this year's play castle were nearly overwhelming: "I redid the panel layouts four times."

David Dear was driven to design his MANO by a roommate who saved every newspaper he read. John Ritson designed his easel bench to be knocked down and mailed to a grandchild. He reports that its recipient uses it in ways he never imagined: She flips the easel over to form a roof so she can play house; she even stands the unit on end as a play store (with awning). Steven Marriott is a quality engineer with the U.S. Army. He and his wife operate a computer programming business out of their home, and he built the drop-leaf desk when he couldn't find such furniture in local stores. Erlin Clement works as a woodworking instructor in the Detroit school system. He set out to design a "grandchild-proof" coffee table that could be climbed on without scattering its contents. J. P. Kurth created the lap desk for his own hobby work while watching television; he found it so useful he wanted to share his plans with others. Appropriately enough, he's an occupational therapist. Richard Cronenwett, an engineering project manager, built the secretary for his daughter.

My hearty congratulations to winners and non-winners alike for making this final competition one of the best in the 10-year series! PS

Credits: Panel diagrams drawn by Carl De Groote. All photos by Strode Photographers, Tacoma, Wash., except where otherwise credited. Area rugs and accessories from JCPenney Co.; typewriter from H. D. Baker, computer equipment from Best, and loveseat from Slyter Chair, Inc., all of Tacoma, Wash.

ORDER PLANS FOR PROJECT CONTEST WINNERS

American Plywood Association
Dept. PS 8/86
P.O. Box 11700
Tacoma, WA 98411

Please send me the following plans at $2.00 each.
Allow three to four weeks for delivery.

Child's Easel Bench	$ ____	Play Castle	$ ____
Lap Desk	$ ____	Storage Coffee Table	$ ____
Drop-Leaf Computer Desk	$ ____	Modular Secretary	$ ____
		I enclose *(total amount)*	$ ____

This coupon is your mailing label.
PLEASE PRINT

Name ____________________

Address ____________________

City ____________ State ________ Zip ________

Secrets of a pro: installing vinyl gutters

Vinyl gutters and downspouts are an attractive alternative to traditional metal troughs, which can corrode or dent. And now, plastic components may be less expensive than aluminum. But you'll need to know a few tricks to ensure maintenance-free installation.

PHOTOS BY RICHARD DAY AND PHIL McCAFFERTY

By RICHARD DAY

If you have ever tripped over a downspout extension, you know how quickly metal gutter parts can depreciate. One misstep can leave you with more than just a bleeding ankle—it can bend or dent the metal. And the first time you lean a ladder against a gutter, you may wreck your drainage system.

Metal is also vulnerable to its environment. It can corrode, and it must be repainted or replaced periodically. And unless you're careful, you may draw blood if you try to install a metal system yourself.

The alternative—vinyl gutters and downspouts—have become widely available in home centers in a greater variety of styles ["Plastic Gutters," PS, July '85]. The price has gone down in comparison to aluminum, too, so that vinyl is now likely to be lower in initial cost as well as in long-term maintenance. (The only possible problem with vinyl is exposure to extreme heat—see box, next page.) Best of all, vinyl gutters are simple to install. Cutting the segments and mounting them on your roof will be an easy task if you master the following tips.

First, remove the old gutter system and all its hardware. Then you will be ready to mark your new gutter's position before attaching it to your roof. Mount the system below an imaginary line extending past the edge of the roof so that ice sheets will slide over the gutter instead of crashing into it.

The more gutters slope, the better they work. But gutters become the visual roof line of your house, so they *look* best when installed dead level.

Intense rainfall, as in the southern states, might require a slope of ¼ inch for every 10-foot length of gutter. This is enough to direct the water flow toward the downspout. A slope of ½ inch gets things moving nicely but skews the gutter enough to make the roof line look "off."

Use a chalk line against the fascia to mark the gutter's alignment. Stretch the line level, then set whatever slope you need by moving one end down the desired amount at a drop-outlet location before you snap the line.

Gutter slope and the intensity of rainfall where you live govern the spacing of downspouts. Most systems are designed for a maximum of three gutter lengths—or 30 feet—between

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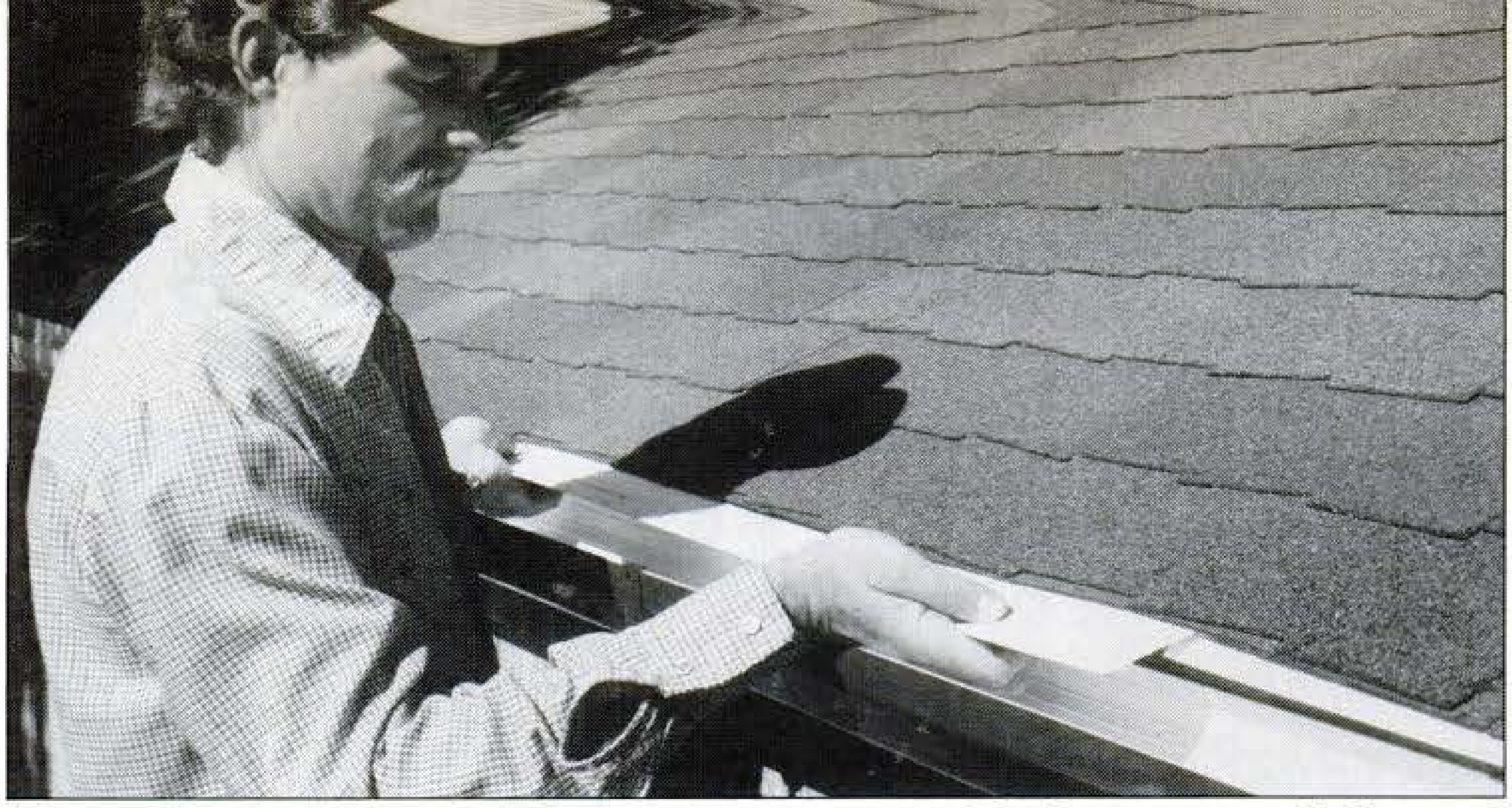
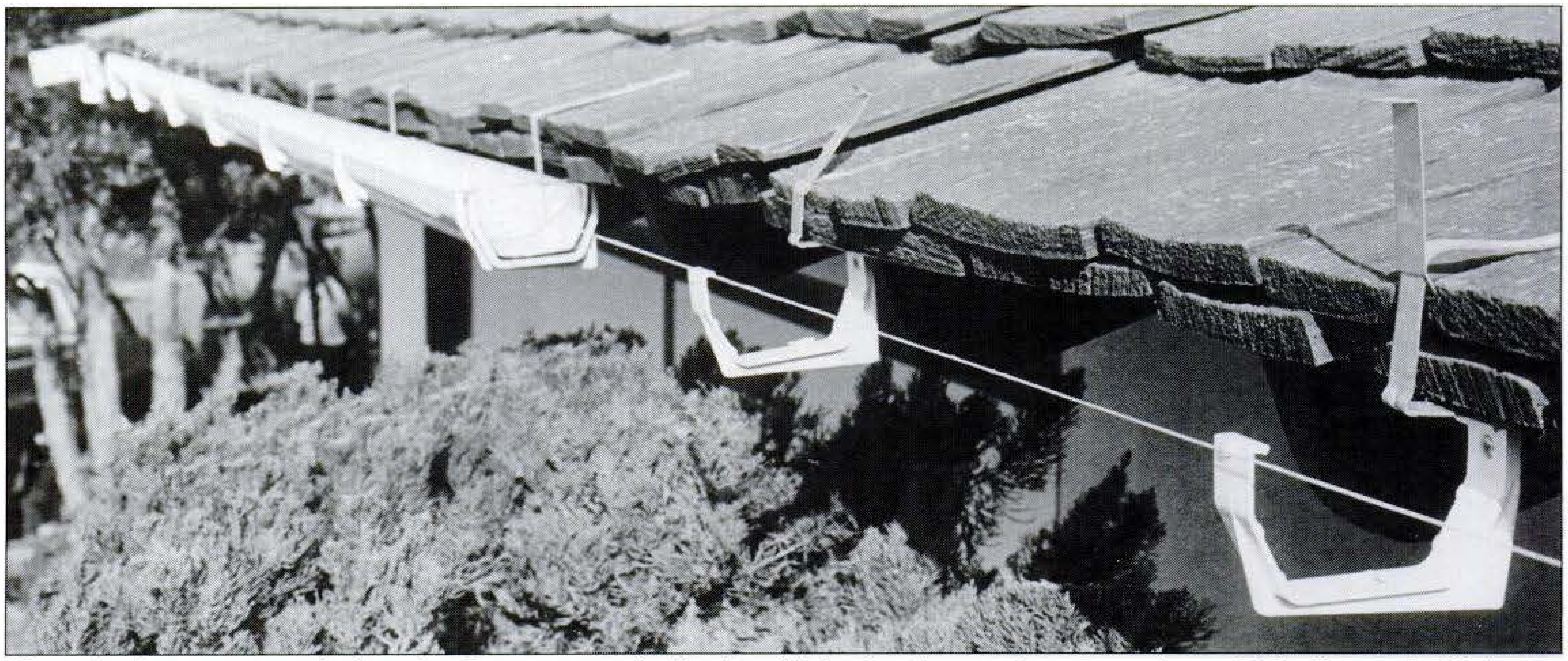


Shingles should project at least ½ in. beyond the roof so that water will run off into the gutters. If necessary, push a vinyl drip edge up underneath the bottom shingles to extend the roof edge. Drip edges are available in 10-ft. strips and can usually be matched to the color of your gutters.

downspouts. If you install level gutters, plan to use a spout every 20 feet, especially in rainy regions.

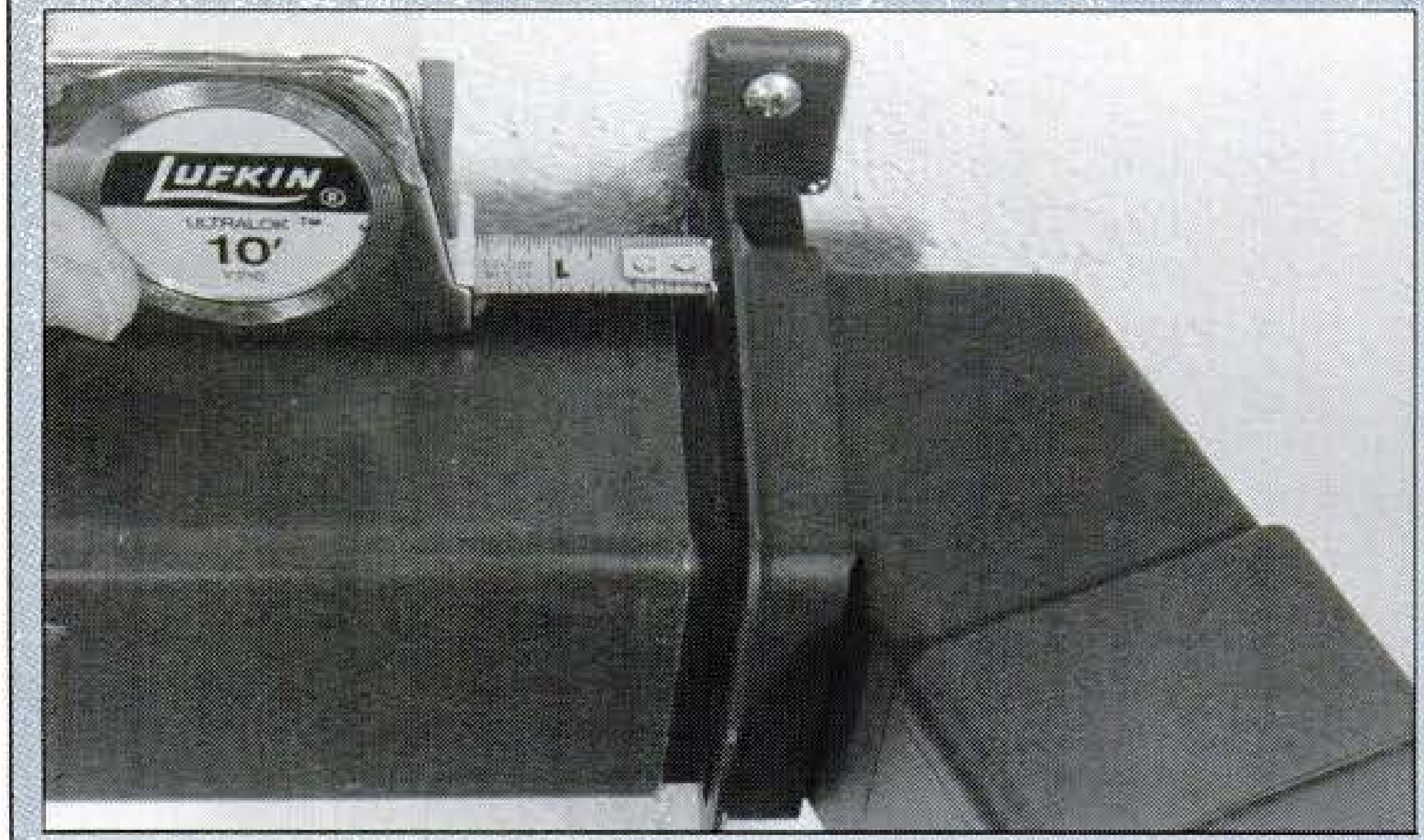
One downspout will serve between 500 and 700 square feet of roof area. After you plan the spacing, make sure you have enough downspouts to drain the area above. An extra-wide house or one with a shed roof might need more downspouts.

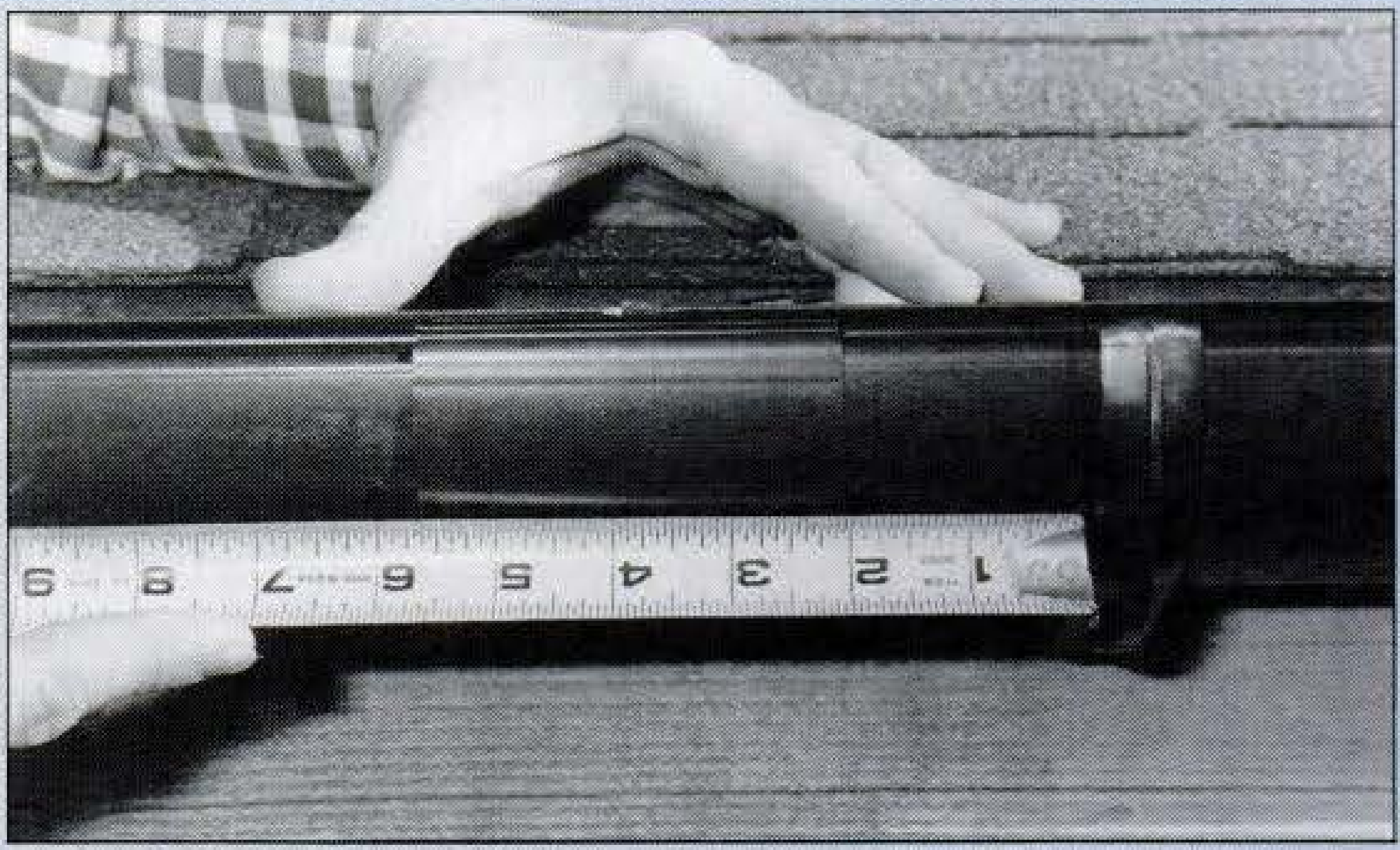
There is one way to minimize the number of downspouts you install. A couple of manufacturers offer high-flow drop outlets that have larger openings with smoothly curved surfaces leading from the gutters to the downspouts. In a conventional system, the water must make a sharp turn



Most vinyl systems are designed to be owner-installed. If your house has no fascia or rafter tails for bracket attachment, use strap hangers aligned to a stretched string. If the fascia or rafter tails are at an angle, use wedge-shaped blocks between the brackets and mounting surface. Space brackets at maximum 30-in. intervals (24 in. for heavy-snow climes); joints, every 10 ft., the length of gutter sections. Make a sketch to plan downspout locations.

You must allow for expansion and contraction





Plastic gutters and downspouts expand and contract more than metal. A 10-foot length of gutter will change in length by as much as ½ inch. Desert areas, where the temperature varies widely from day to night, put the most strain on plastic systems. But you can overcome stresses by allowing for expansion and contraction when you install the gutters.

If you use a system with slip joints, align the ends of gutter sections with the marks inside the joints. Leave ¼ inch for downspout expansion just below the upper spout elbow on the house wall (above left). On a two-story downspout, tuck in another expansion space just beneath the downspout coupling. Some instructions call for a ½-inch space, but ¼ inch works just as well and looks better.

A solvent-welded system requires more space for movement because you are forming it into one long piece. With gutter corners at both ends, put an expansion joint in the run to prevent buckling (above right). Leave at least two inches between the gutter brackets and joints so the gutter can slide around a corner to enter the downspout. With sloped drop outlets, water exits more quickly without forming a vortex. Maximum downspout spacing can be increased to 40 feet, and roof area served to about 1,200 square feet per spout. This method is cheaper and easier than adding another downspout.

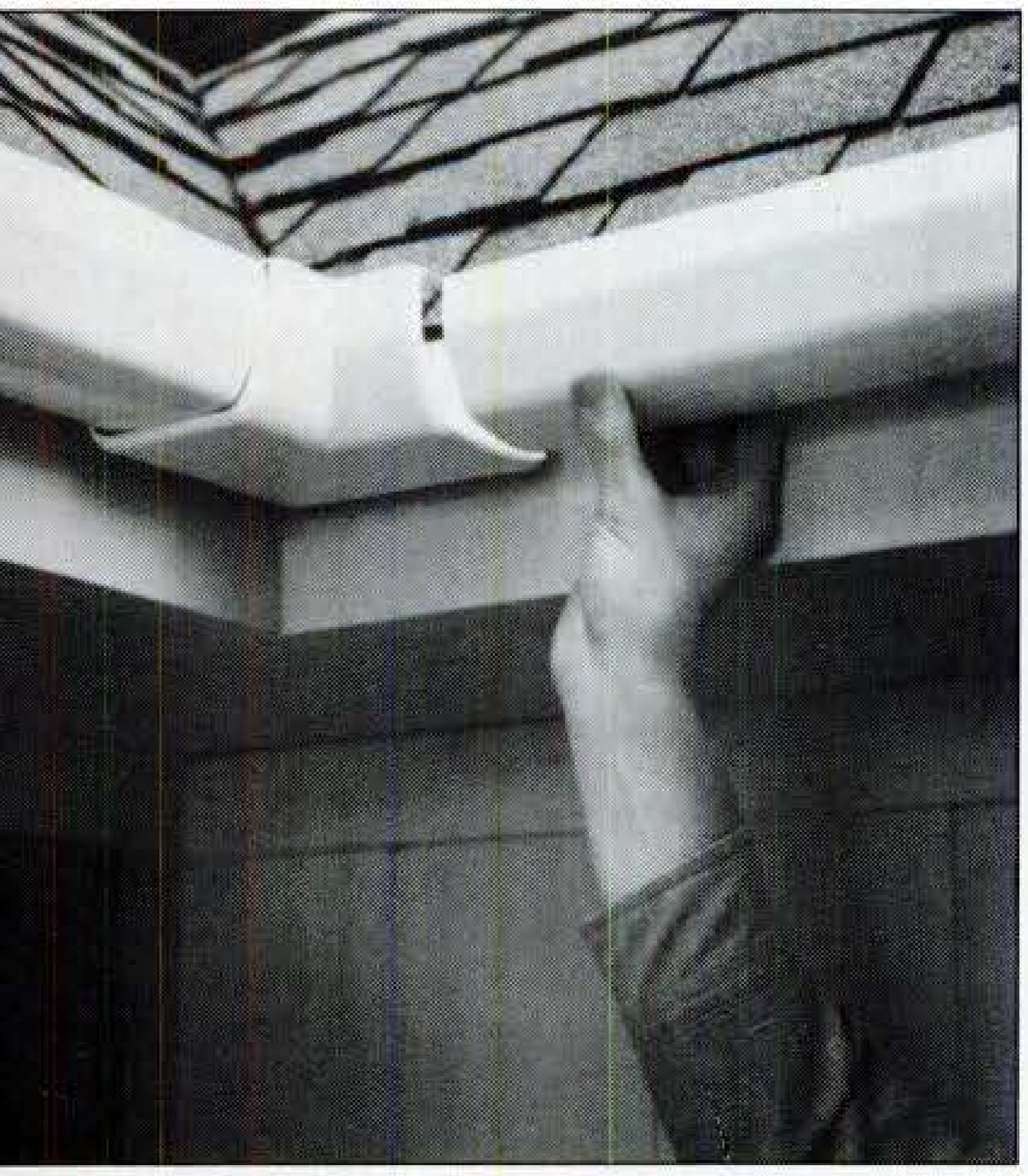
Other systems are especially slow drainers. Some have drop outlets that are solvent-welded into holes cut in the bottoms of the gutters. Each drop outlet has a flange that is welded to the gutter bottom; this means the downspout cannot be nearly as wide as the gutter. Thus the downspouts must be more closely spaced.

If your house was built with uniform overhangs, you may be able to replicate the downspouts. Make up one, and take it around to the other spout locations to see whether it fits. If so, you can precut all parts on a radial-arm or table saw. A fine-toothed plywood-cutting blade is best. Feed slowly to minimize chipping, and wear face protection.

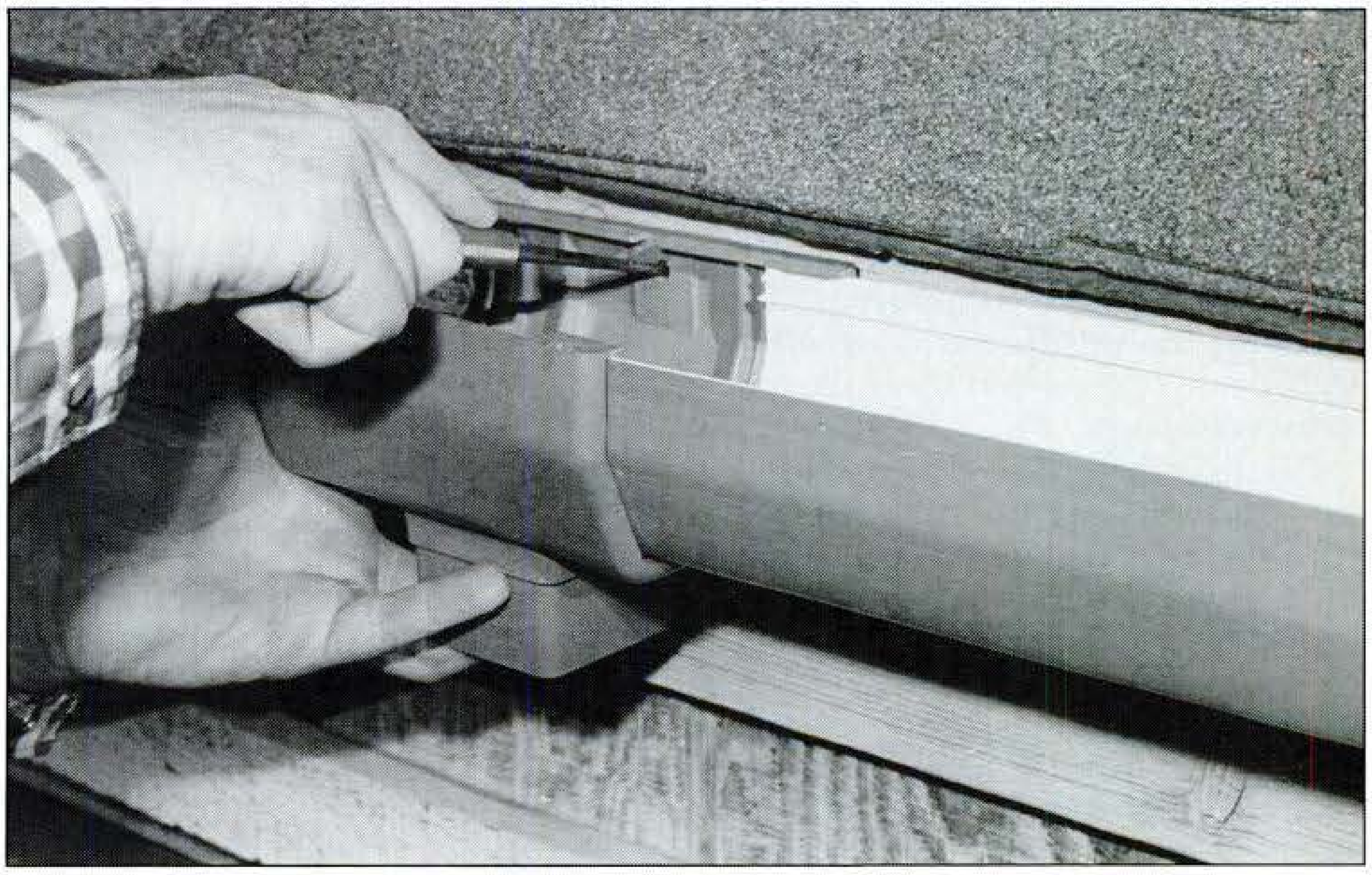
Runoff from the downspout should empty at least 18 inches from foundations. Some systems offer swing-up extensions to keep water away from your house—one reason for installing gutters in the first place. Or you can connect underground storm drain pipes to your downspout system, if the manufacturer offers a drain adapter.

If you don't like the color of your gutters, you can paint them. Wipe them down with denatured alcohol before you begin. Use exterior latex house paint or exterior enamel. If the surfaces are glossy, you may need a primer that will bond to the vinyl. One manufacturer offers a specially formulated satin-finish brown paint for use as either a vinyl primer or a finish coat.

Remember that if you paint your system, you will have to renew the coating in years to come. Yet even with this inconvenience, vinyl gutters are easy to maintain and will last for years if you install them properly.



Gutter segments can fit into an inside corner joint. If roof lines don't meet at a right angle, use a saw to take out a wedge or make custom corners.

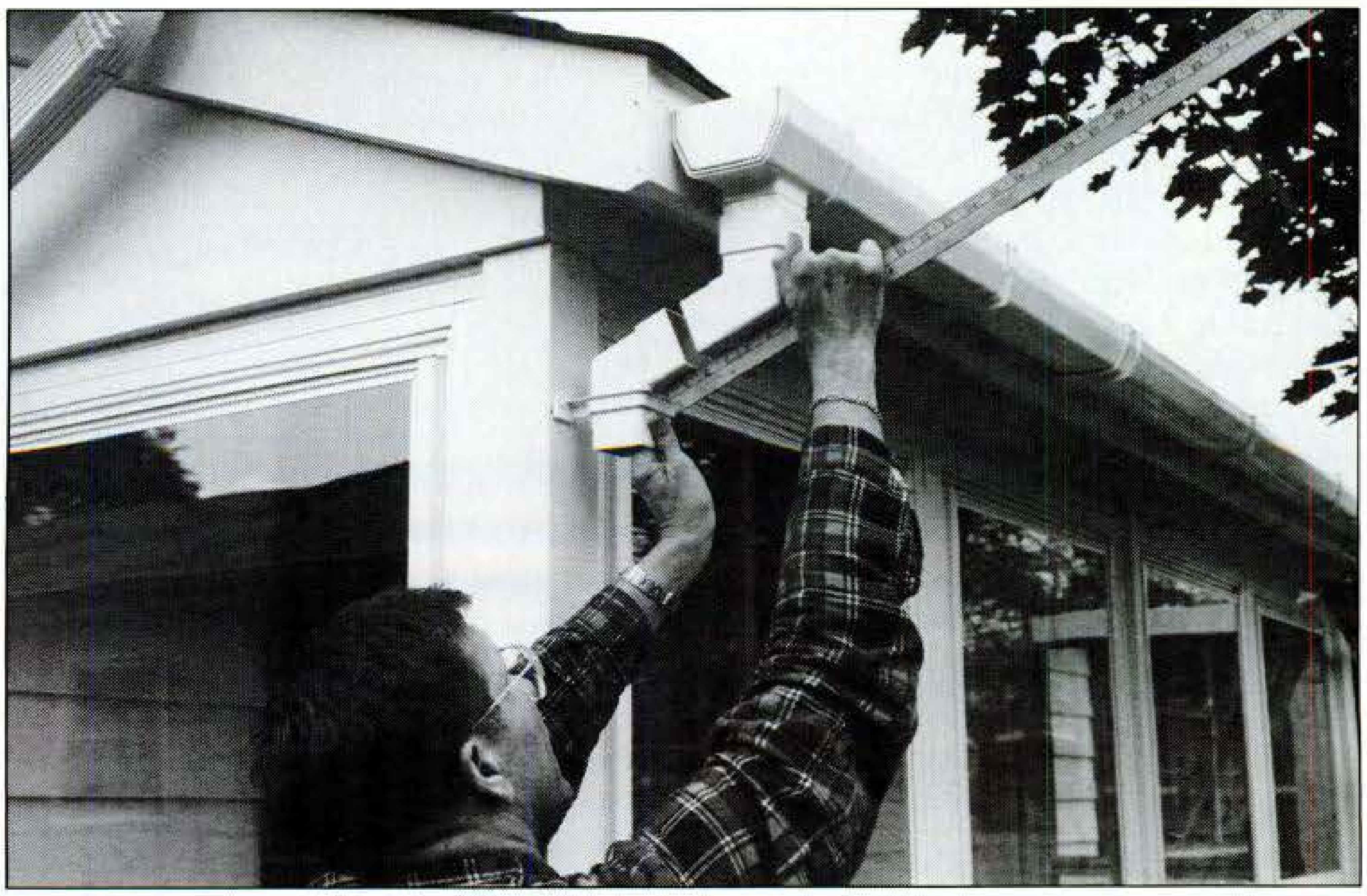


Installing lengths of gutter with a slip joint attached saves having to measure for joint placement. Cut the gutter sections to the proper length beforehand, keeping in mind the clearances needed to avoid buckling. Gutters may be slid, snapped, or solvent-welded together, depending on the brand.

freely. And remember not to weld expansion joints, downspout elbows, and gutter brackets to the gutter.

Ice will not crack a vinyl system, and it won't adhere to gutter sides any better than it sticks to ice-cube trays. But solar heat can be damaging because vinyl is a thermoplastic that becomes soft when it gets too hot. One Phoenix homeowner learned this lesson the hard way: He painted his entire system brown, and the heat it absorbed warped it. The insides of gutters should always be white, to reflect the sun's rays. The outside—the part you see—can be any color you like. Although gutters now come in both dark and light colors, some manufacturers have developed more sophisticated two-tone gutters with dark exteriors and white interiors.

Reflective metal awnings, porch roofs, and patio covers may cause special problems: They reflect solar heat onto the outside of the gutter. Use all-white gutters and accessories above these surfaces. While installing your gutter system, do not lay any parts out on a blacktop driveway. Absorbed solar radiation may deform them.—R. D.



Start the downspout by mounting an elbow in a bracket. Align it with the gutter elbow, as shown, and mark the hole positions for drilling. Measure the gap between elbows, and assemble with a downspout section of proper length. Attach brackets at each elbow, top and bottom, and at any couplings.

Concrete lawn furniture

—easy with packaged dry mix

To celebrate Sakrete's 50th anniversary, PS commissioned these novel projects that you can make in a day—to last forever.

By DOUG DEEDS
With Susanne and Mike Stevenson

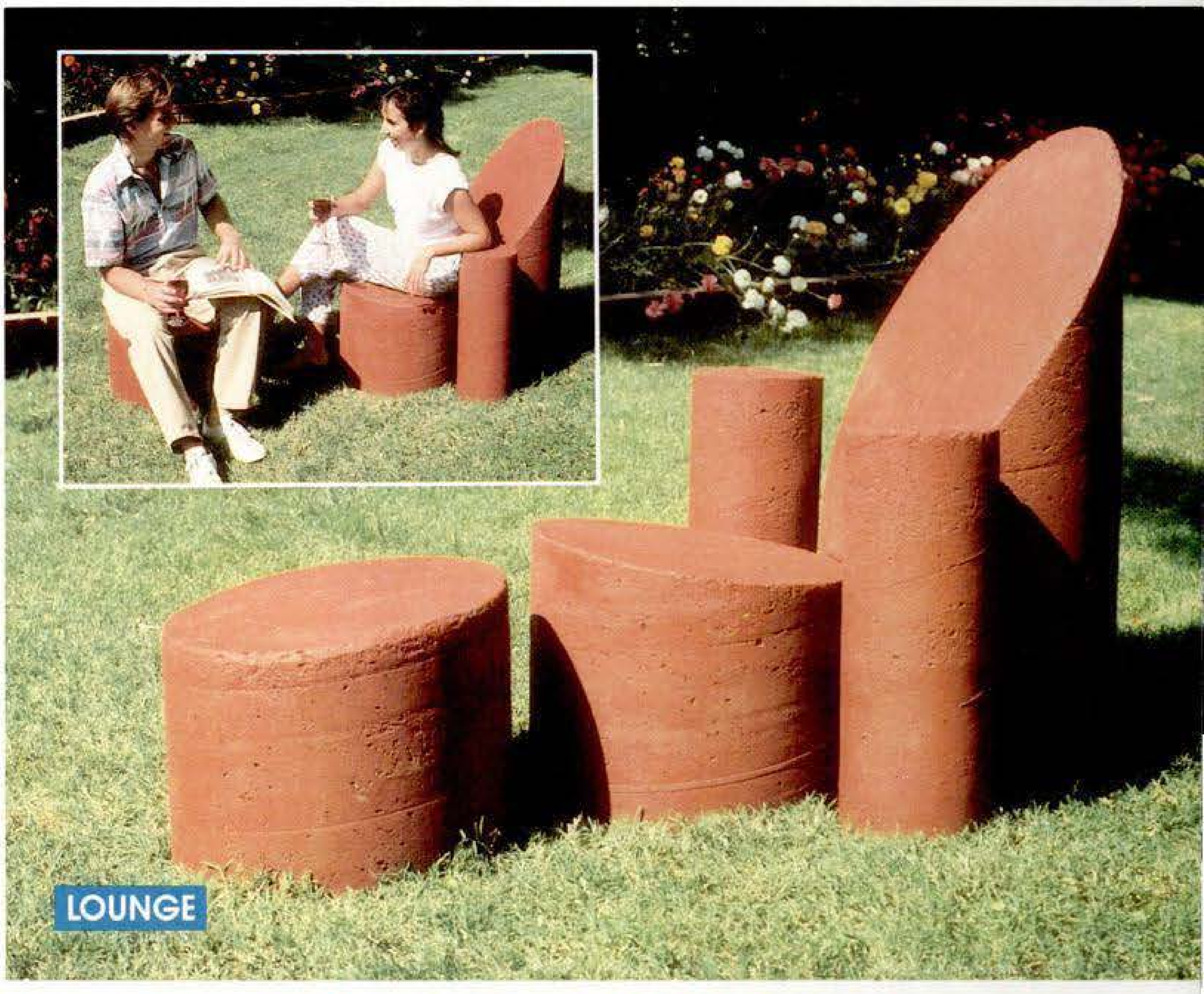
When Popular Science asked us to design a project for Sakrete's anniversary, we tried for the unexpected—something that would take advantage of the product's versatility.

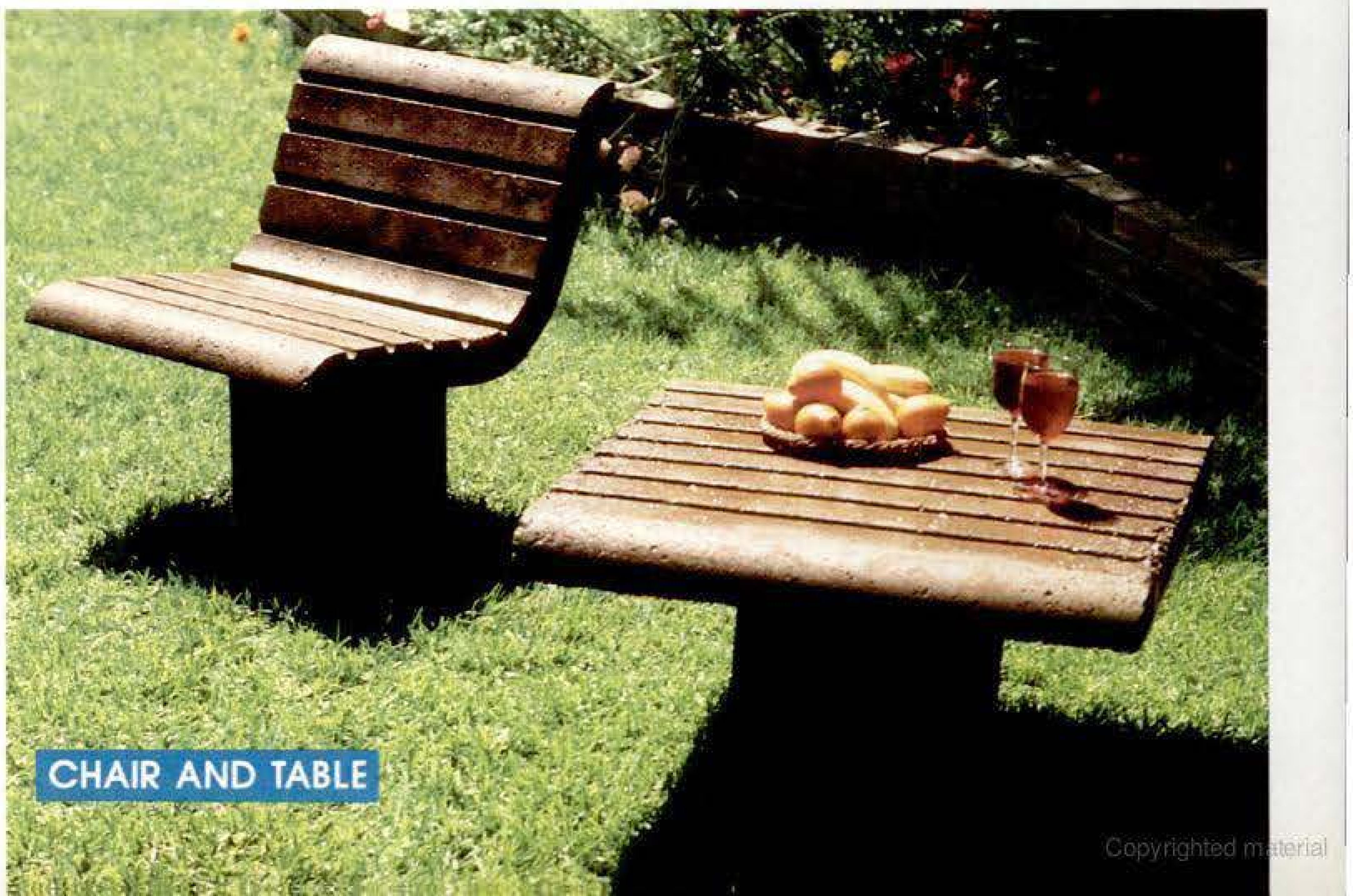
All cylindrical components of the furniture are cast in cardboard forms—of eight-, 14-, and 18-inch diameters. These are available at concrete supply outfits and many home centers. (Sonotube is one major brand.) There's a special release agent for use with such tubes, but it's usually sold only in large quantities, so we just sprayed the insides of the tubes—and the molds we made for the chair and table—with Pam cooking spray.

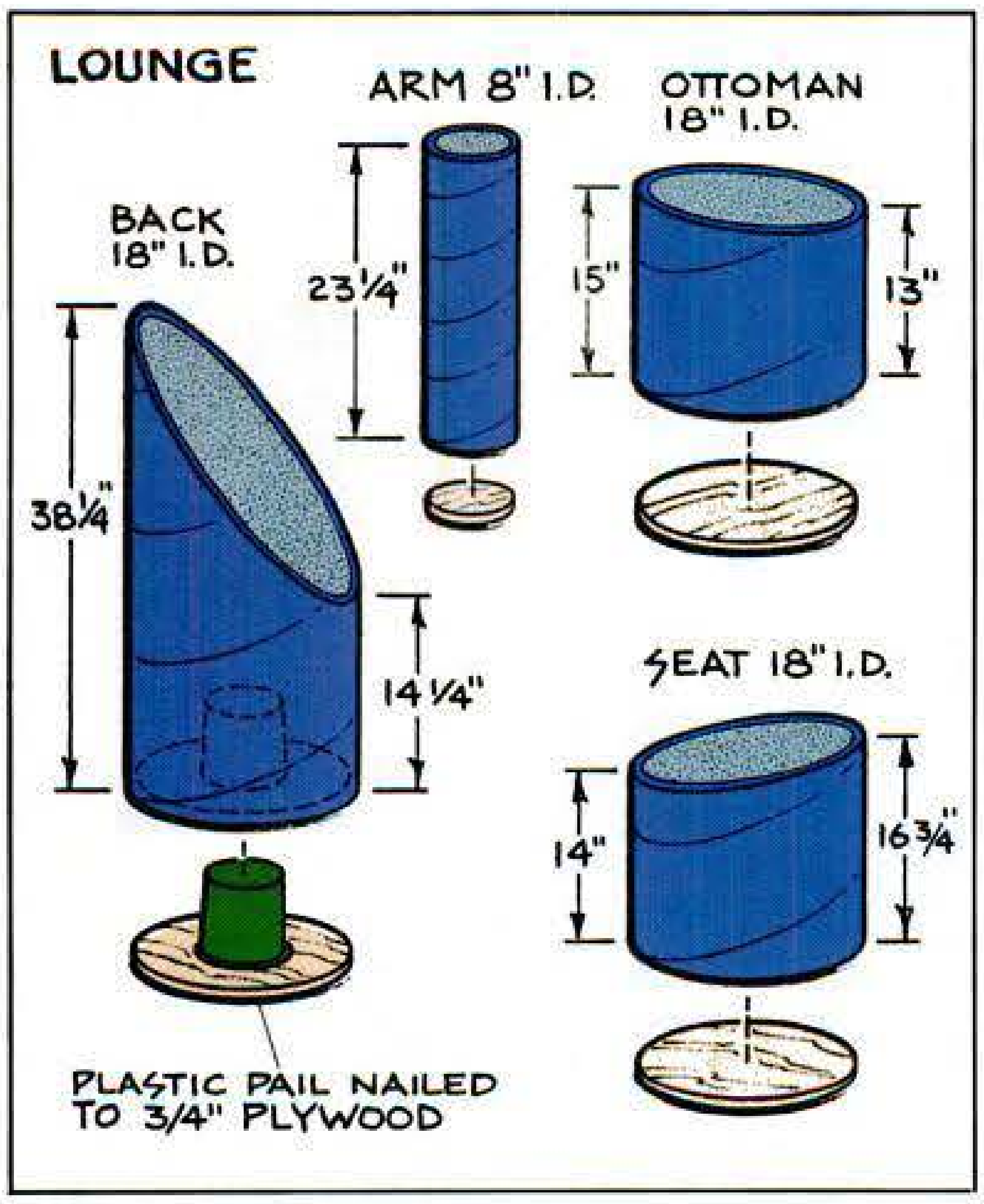
The tubes are easily cut with a handsaw or sabre saw. Mark straight cuts by wrapping aluminum flashing around the outside.

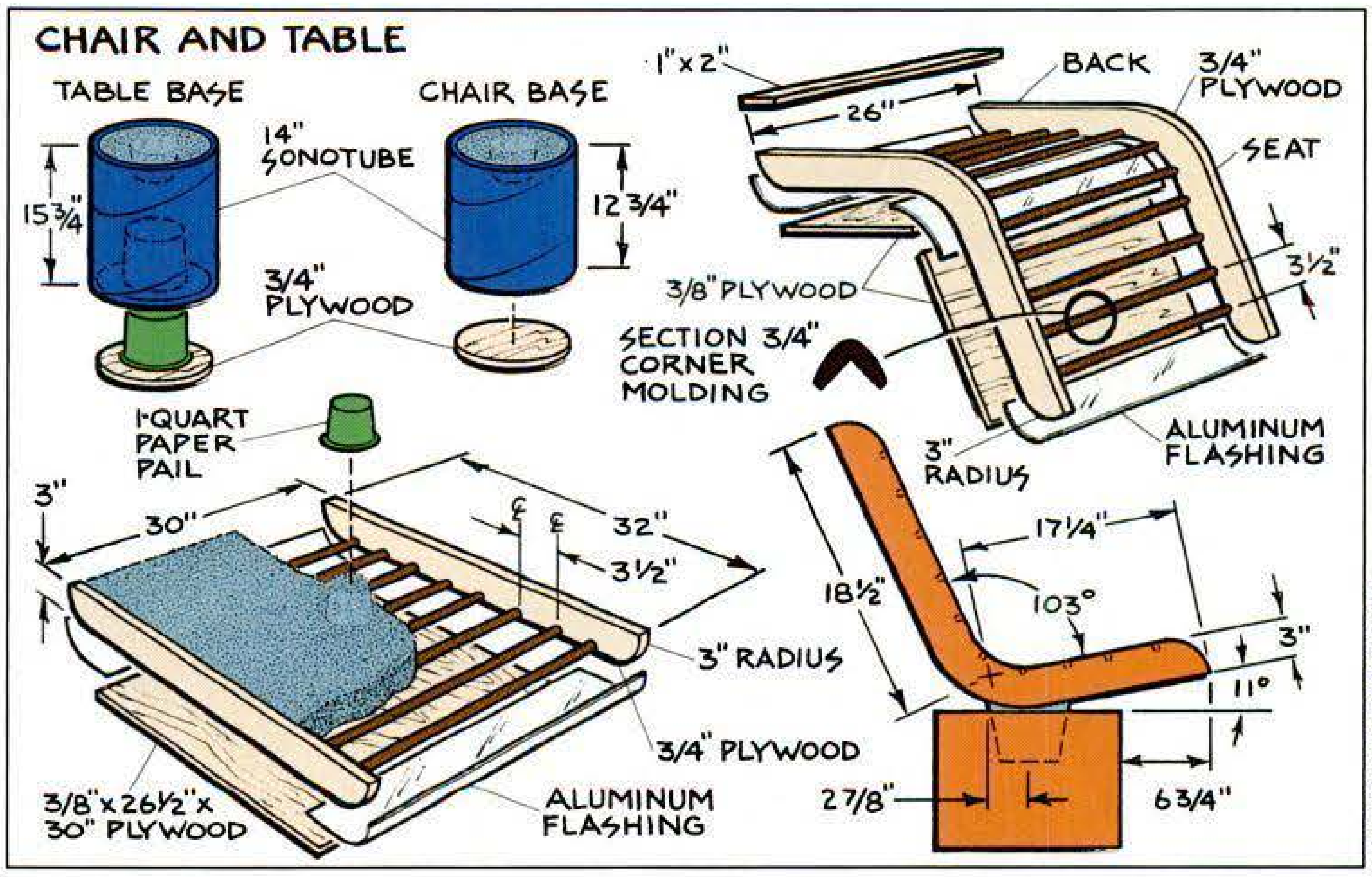
To reduce the volume and weight of the pieces, we nailed cheap plastic pails to the end discs before inserting them into the tubes and fastening with box nails driven into the edges every 2½ inches. The tops of the chair and table bases should also have depressions—large enough to take stubs on the bottoms of the form-cast uppers. Make these stubs by filling a quart-sized paper bucket with concrete and inverting it on the fresh pour. (Insert a steel rod for reinforcement.) The back section of the lounge is cast by laying it in an angled dirt trough so the long bevel stays horizontal.

It's easy to peel off the tubes 24 hours later because they've absorbed moisture from the pour—just take care not to break off any edges. After a week's curing, apply a concrete paint to exposed surfaces. Line the sockets in the table and chair bases with mortar, and set the tops in place.

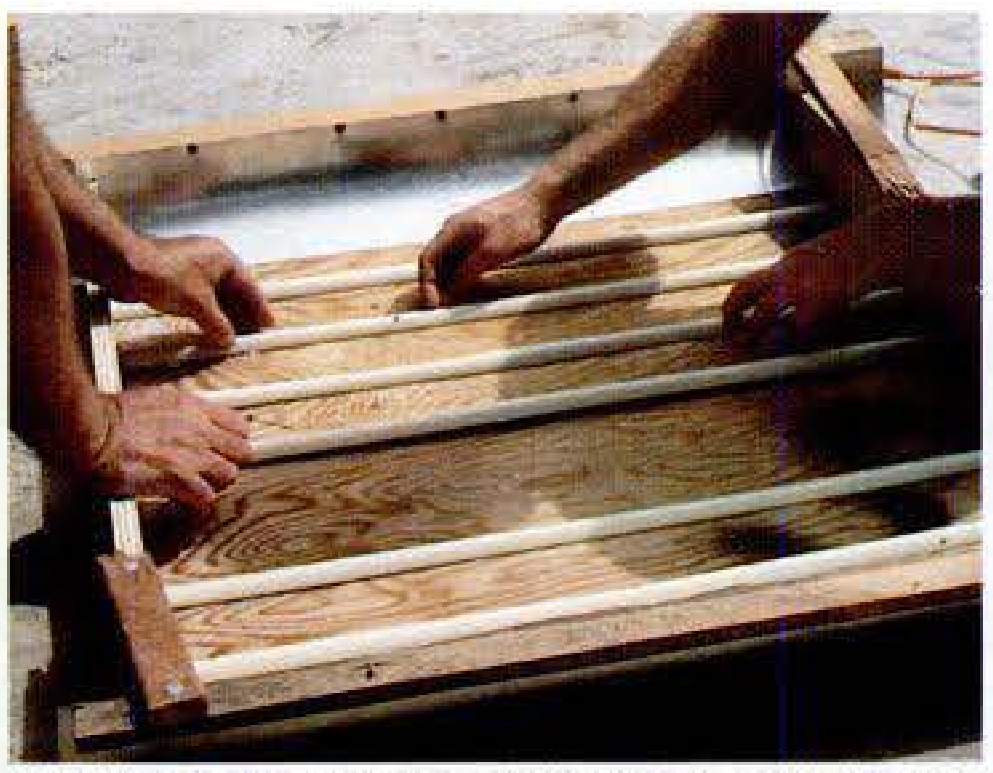

LOUNGE

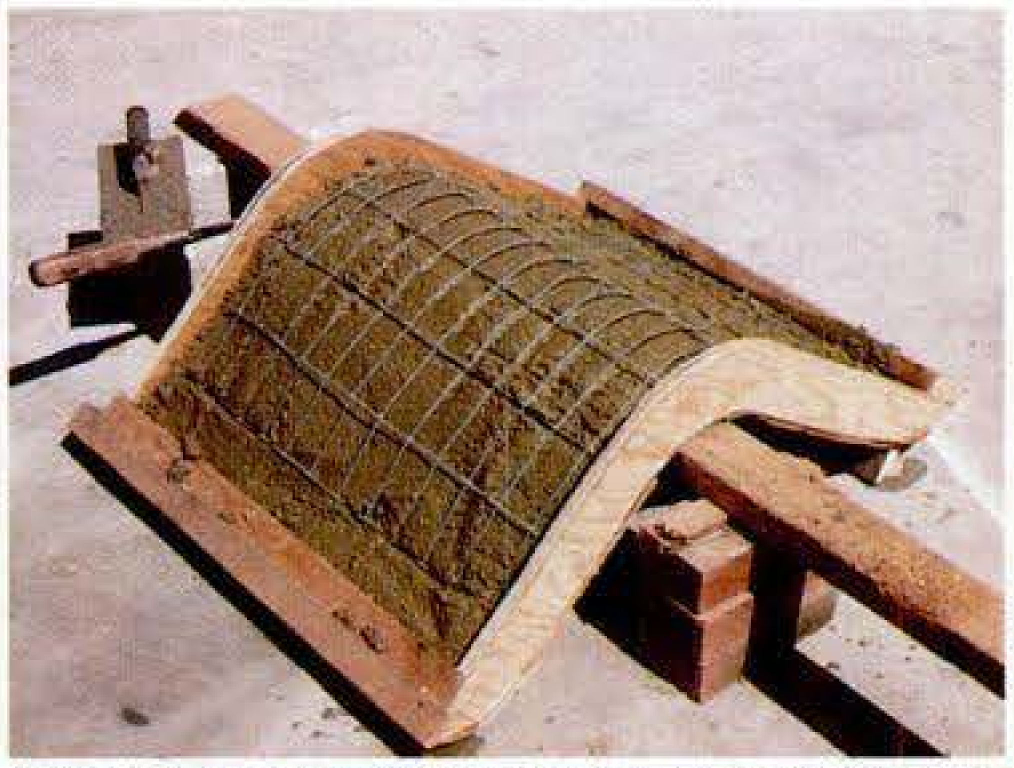

CHAIR AND TABLE





DRAWINGS BY GERHARD RICHTER





Ribs, to create the slat effect, are molding strips glued across bottom of forms before concrete is poured in. In right photo, one-half of the stiff mix has been placed and reinforcing mesh laid on top before the other half is poured. Form is plywood; aluminum flashing strips are tacked on to form curves.

Sakrete's founders still run the company

CINCINNATI

I got the grand tour when I visited Sakrete's pilot plant, just north of this lovely river city. I was greeted by the company's founders, Art and Mary Avril. As Art set off briskly to lead us through the steps of preparation and packaging, Mary filled me in on the beginnings. Art opened this city's first ready-mix plant in 1929, and was struck with the number of people who'd come by asking for a bucket of "drippings" for minor concrete jobs around their homes. "Think of the thousands of small-batch customers out there!" he said to Mary.

Art was well versed in the tricky technology of making quality concrete: In bidding for early jobs, he'd created the idea of a guaranteed strength (in the pounds per square inch that concrete withstands before cracking), so had taken all guesswork out of the mixing process. But could he now come up with exactly proportioned, pre-mixed dry ingredients he could ship in a moisture-proof package for sale to amateurs who'd only have to add water to get perfect concrete for small jobs?

The answer was yes, and the rest is history. Exactly 50 years ago this month, Art and Mary shoveled the magic mix into multiwall paper bags and trucked a batch to their first customer.

Actually, from the start there were three mixes: a 4,000-psi concrete mix (used for the projects on these pages), a 5,000-psi sand mix (for resurfacing), and a 1,250-psi mortar mix (for laying brick and block). Art's original formulas for proportions were so precise they've remained unchanged. And the goof-proofing came from the product's simplicity: A 90-pound bag of mix takes one gallon of water to yield four square feet of concrete two inches thick. All this was all set in 1936.

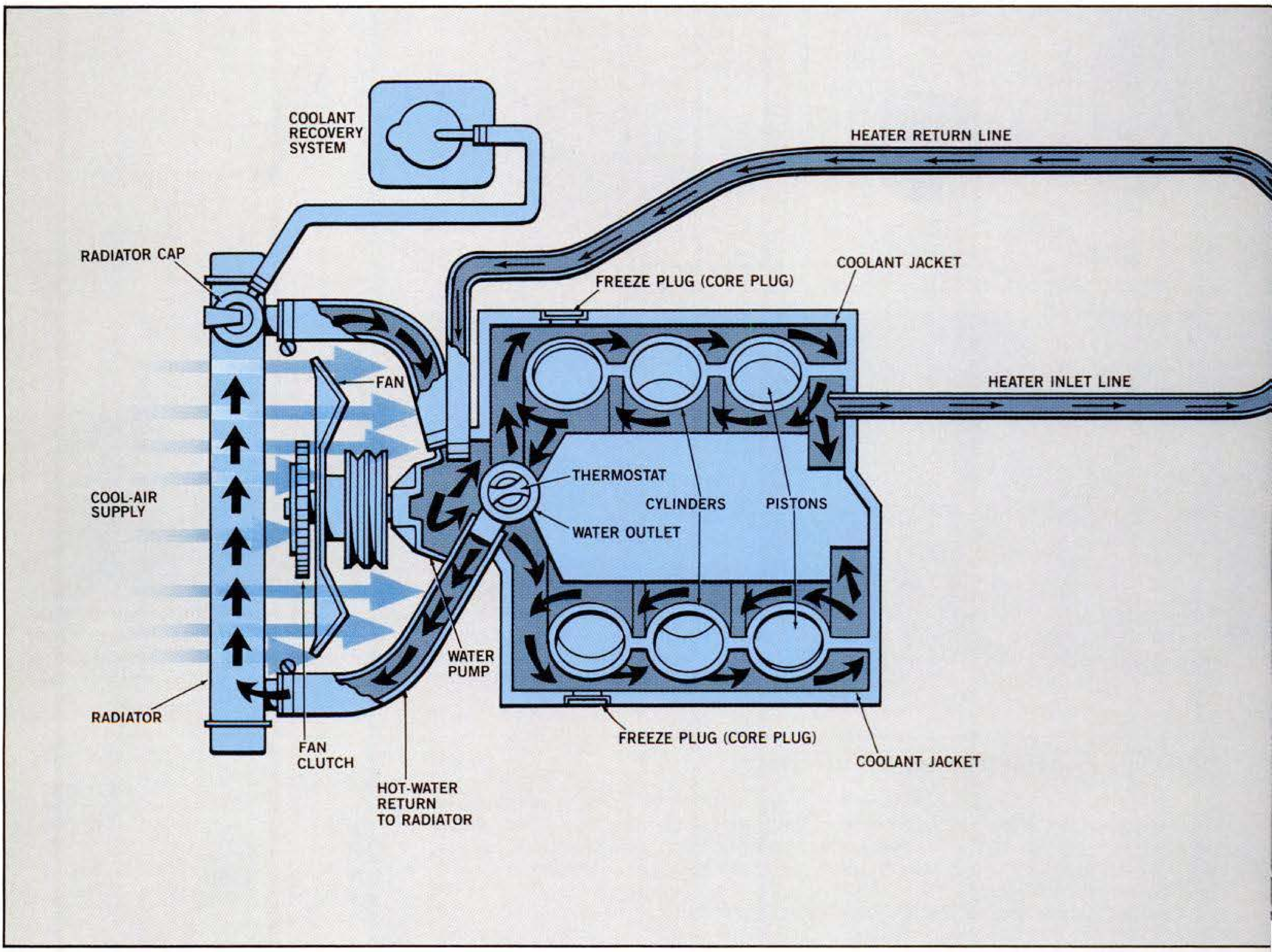
Nor has the manufacturing process changed much, as Art showed me on our tour. To rid ingredients of natural moisture, sand goes into a rotating drum of Art's design, where it's heated to 275 degrees F; then gravel is introduced. "We used to have two drums flaming away here," Art shouted over the din of the tumbling aggregate, "until I found the hot sand could dry the gravel—that cuts fuel costs." So the aggregate is now rescreened, then recombined with cement added (all proportions measured via electronic scales), and fed into gravity loaders that fill one bag at a time as it moves down a modest assembly line in the packaging plant a floor below. There are actually three lines moving simultaneously down here—one for each mix—and this plant fills 6,000 bags a day. Since dry mix is heavy, the trick is to keep trucking distances short. That's why you'll find regional Sakrete plants all over the U.S.—and much of the world.

The Avrils check results of a compression test conducted for PS Home and Shop Editor Al Lees (right). A cylinder of cured concrete was placed on end in a hydraulic press until it fractured.

"We've never gone after a licensee," Mary told me. "They've all come to us, one by one."

As I left for New York, I exchanged bon voyages with Art and Mary. They were off to Germany for a meeting of representatives from the 15 Sakrete plants there. For the record, Art's 85 years old and Mary's a couple of years younger. As active heads of the company they founded, they're probably unique in U.S. industry.—Al Lees

Keeping your car's



By BOB CERULLO
Drawings by Russell von Sauers

The scent of boiled coolant, the billowing damp clouds of under-hood steam, the impatient horns of overheated drivers: For many motorists these are the all-too-familiar signs of summertime driving.

A recent survey done by the federal government in California found that, after flat tires and running out of gas, cooling-system failures were the most common cause of breakdowns. But you don't have to be caught by the side of the road. Instead, you can get ahead of cooling-system problems in the shade of your driveway or garage.

In the following pages, I'll highlight what I've learned over 25 years in auto maintenance concerning

- Simple, routine cooling-system maintenance that will prevent most problems.
- How to track down leaks.
- How to diagnose the tough problems that don't involve a leak.

Leakless overheating

Overheating can be caused by many things other than coolant loss. So before you start hunting for leaks, give these areas a quick check.

The first place to look is the front of the radiator. Is it clogged with bugs and debris? Did someone shove a piece of cardboard in front of it to speed engine warm-up this past winter?

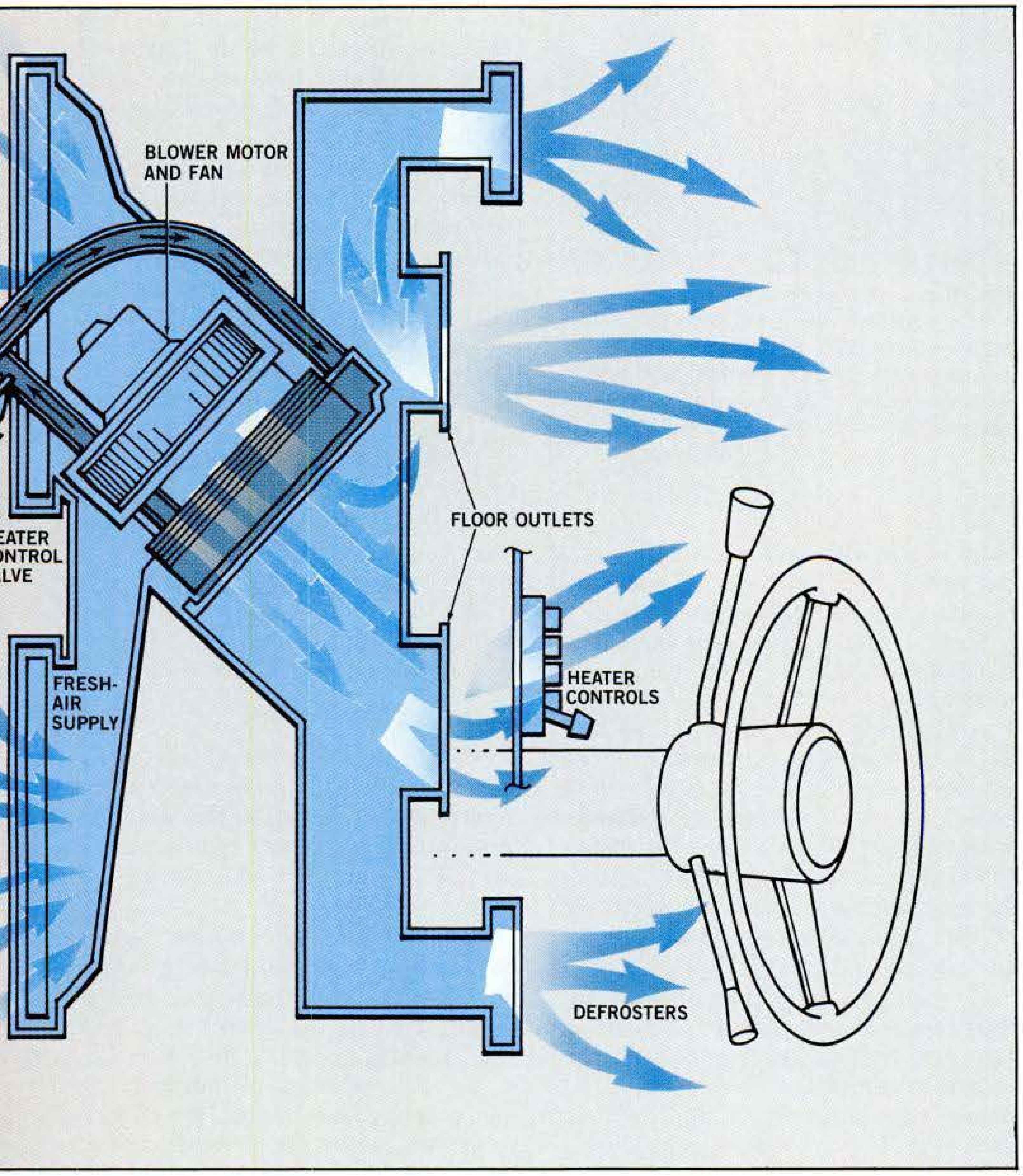
The next thing to check is the ignition timing. Extremely late or retarded ignition timing can cause combustion-chamber temperatures to soar as high as 4,500 degrees F—more than twice the normal temperature of 2,000 degrees.

Then check the thermostat. During engine warm-up it remains closed and blocks the flow of coolant to the radiator. But it should open when normal operating temperatures are reached. When the thermostat fails in the closed position, coolant is unable to get to the radiator—and the engine quickly overheats.

All you need for this check is an accurate thermometer, a pan of water, and a stove top. Suspend the thermostat in the water without its touching the pan's sides. Gently warm the water so the thermostat opens just enough to slip a thread between the valve and seat. Now let the thermostat cool so it closes, taking a bite on

cool

An auto pro takes you step by step through your car's cooling system to help you spot and fix trouble before you're left stranded.



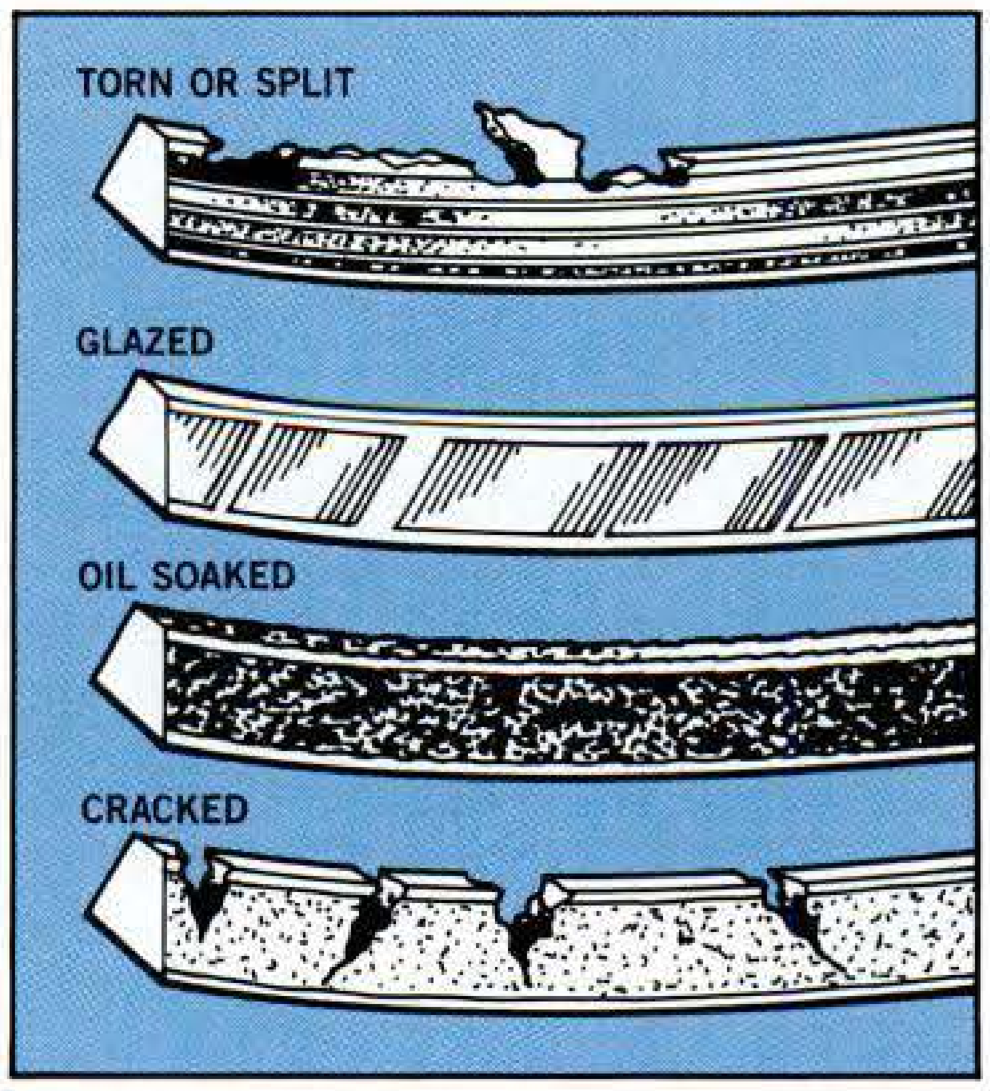
Combustion-chamber temperatures in an engine can reach as high as 4,000°F. About one-third of this tremendous heat energy is used to drive the pistons up and down to turn the crankshaft. Another third is lost out the tailpipe. The remaining third must be removed by the cooling system. To do this, coolant (ethylene glycol and water) leaves the bottom of the radiator. The coolant is pumped into the warm engine block, where it circulates around the hot cylinders in passages called cooling jackets. From the block, the coolant moves to the hottest part of the engine—the cylinder head. Some hot coolant is diverted to the heater core when the heater control valve is open. From the cylinder head, the coolant returns to the top of the radiator. A thermostat located at the engine outlet restricts coolant flow until the engine reaches the specified opening temperature to speed engine warm-up.

the thread. Then immerse the thermostat again, and slowly rewarm the water. When the thermostat drops off the string, read the thermometer for the opening temperature.

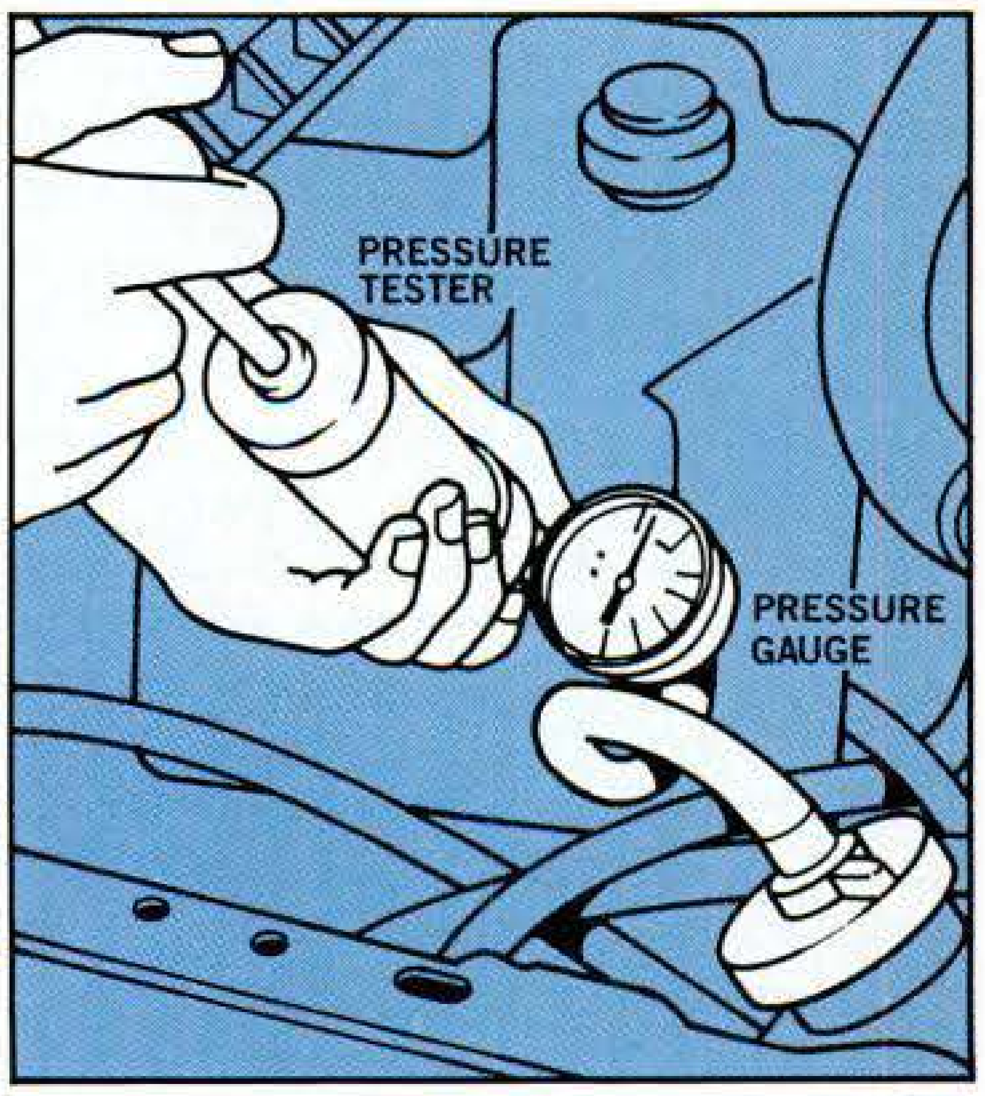
If your car has one, take a moment to examine the fan clutch. The clutch allows the engine-driven fan to freewheel until the engine gets hot. Because the clutch assembly moves freely, a problem here is sometimes hard to diagnose. I've found it helps to listen for the change in fan noise when the engine begins to warm. Start with a cold engine. After it runs for about 10 minutes, you should hear an obvious change in the sound of the engine as the clutch engages.

Many modern cars, particularly front-drives with transverse engines,

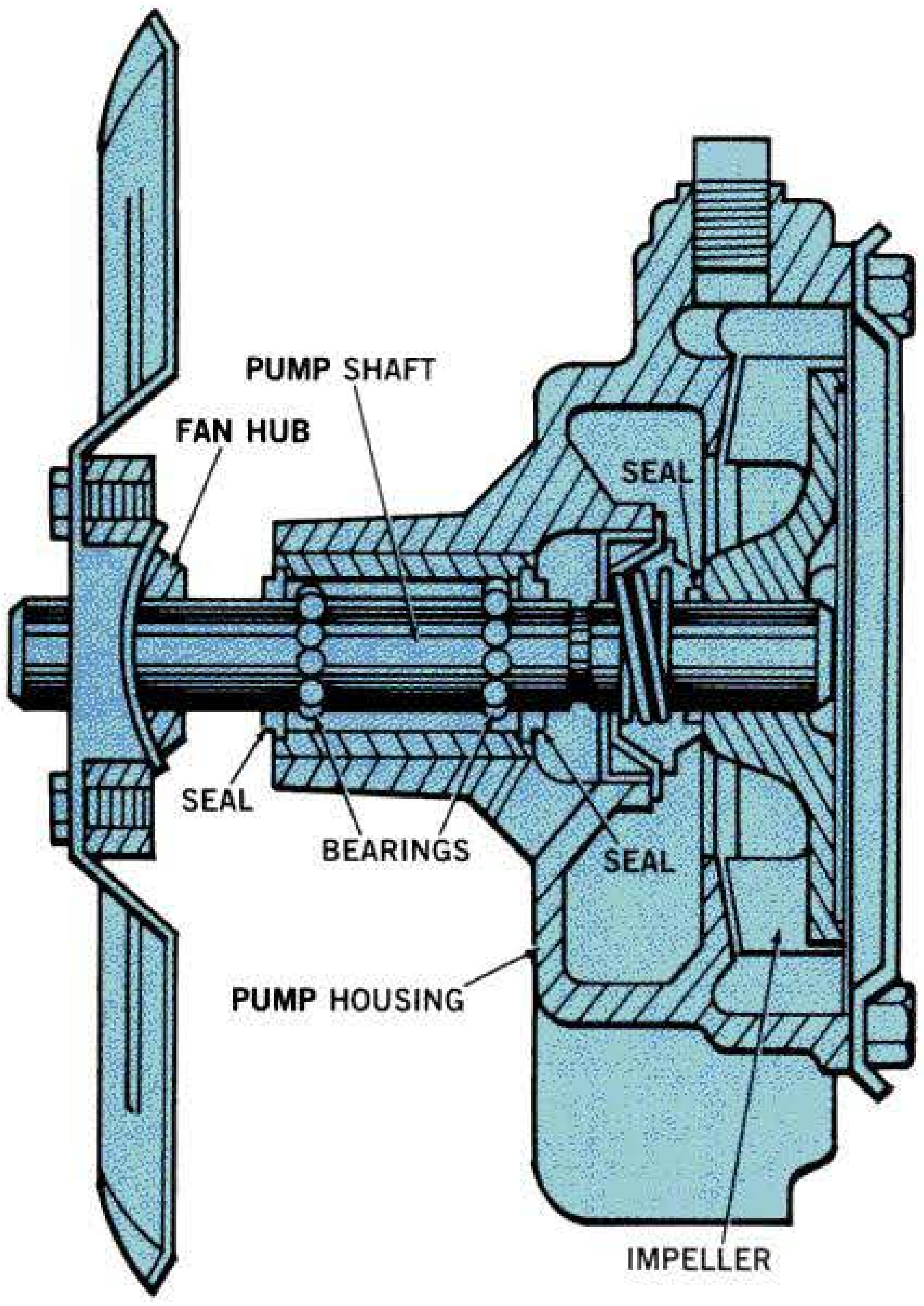
Continued

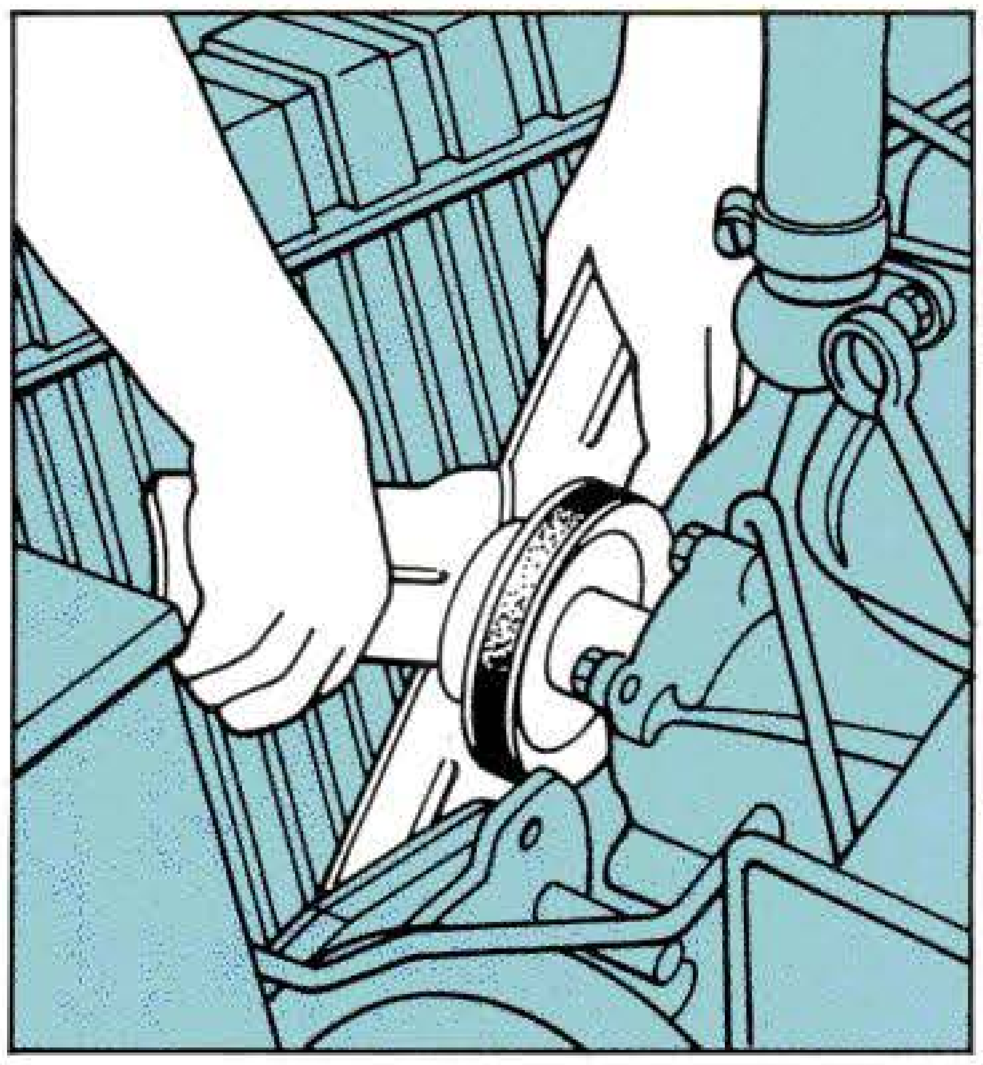


Twist the drive belts to examine them thoroughly. The outside face of the belt may look healthy, but it might be disguising an imminent break.



Pressurizing the system with a leak tester is a safe, effective way of tracking down small, hard-to-find hose, radiator, and heater-core leaks.





To check the water-pump bearings (cross section), disconnect the vehicle's battery terminals; then firmly grasp the pump pulley or fan blades, and try to rock the pump. There should be no discernible movement at the pulley.

use a thermostatically controlled electric cooling fan. Make sure the fan goes on after the engine warms up.

Belts are an easily overlooked cooling-system gremlin. They can contribute to cooling problems in several ways. The most obvious problem occurs, of course, when they're broken. But a tough-to-diagnose problem can also occur if the water-pump drive belt is loose or worn.

Coolant loss

If you lift the hood and are warmly greeted by a cloud of vapor spouting from a burst hose or a hole in the radiator, diagnosis is easy. Things get tricky when the engine overheats and there are no obvious leaks. Here's how I go about tracking down hidden cooling-system problems.

First, pressurize the cooling system. There are two ways to do this: Either let the engine run or use a pressure tester. Unfortunately, running the engine heats up the coolant and system components.

If you're able to get a pressure tester, remove the radiator cap (on a cool engine) and install the tester in its place. Then pump the tester until its gauge displays the system's maximum allowable pressure. Most modern cars use a system pressurized to about 18 psi. Check the rating of the radiator cap, or see the service manual. You can then slowly make your way around the engine bay, checking for loose hose clamps, seeping radiators, weeping water pumps, and dribbling core plugs.

One of the easiest components to examine for leaks is the radiator, but it's important to look carefully at both sides of the core and the area around the end tanks. Be especially critical of areas hidden by the fan shroud.

Some water pumps will leak during a pressure test; others won't leak noticeably. The best time to catch sneaky pump leaks seems to be during temperature transitions. Keep an eye on the pump during warm-up or cool-down. Most pumps have a small weep hole on the underside just below the pump shaft. A leak will either force noticeable amounts of coolant out of this hole or leave traces of dried coolant around it.

Core-plug leaks are some of the toughest leaks to detect. Core plugs are those half-dollar-size plugs driven into the side of the engine block. By using a pressure tester and a lift or jack stands, you have a good chance of spotting this problem.

After a few minutes, you'll find yourself back at the tester. Has the needle dropped on the pressure gauge? If not, there are no leaks. If it has dropped and you didn't discover any leaks, the problem may be hiding in your car's heating system or inside the engine.

Looking for heater-system leaks includes checking the heater hoses from the engine block, the heater valve, and, of course, the heater core. The first signs of a heater-core leak are usually windshield fogging when the defroster is used or wet carpeting on the passenger side of the car. On some cars the coolant from a core leak may drip from the air-conditioner drain hose onto the pavement. Rub some of the discharge on your fingertips. Is it slippery when you rub your fingertips together? Does it smell like coolant? If so, perhaps you've found your culprit. If not, it's time to move on to more complicated problems.

Internal leaks

Diagnosis of internal coolant loss through a leaking cylinder-head gasket, cracked cylinder head, or cracked block is usually difficult. In those cases, the coolant is being drawn into the combustion chamber and eventually discharged from the tailpipe in the form of steam.

But while coolant is leaking into the combustion chamber, exhaust gas is leaking into the cooling system. This provides a way to determine whether a coolant/exhaust-gas exchange is taking place. The vapor from the radiator can be analyzed to determine whether it includes any exhaust gas. In my shop, I use either an exhaust-gas emissions analyzer or a handy little device called a Combustion Leak Tester ($22.50), made by Cal-Van Tools (1500 Walter Ave., Fremont, Ohio 43420). With the tester, a sample of vapor from the radiator filler neck is drawn through a special blue indicator liquid. If exhaust gases are present, the liquid turns yellow.

Keeping your cool

One of the easiest-to-prevent causes of hidden overheating is rust clogging due to neglect, so one of the best ways to maintain your car's cool is to flush out all of the old coolant every two years.

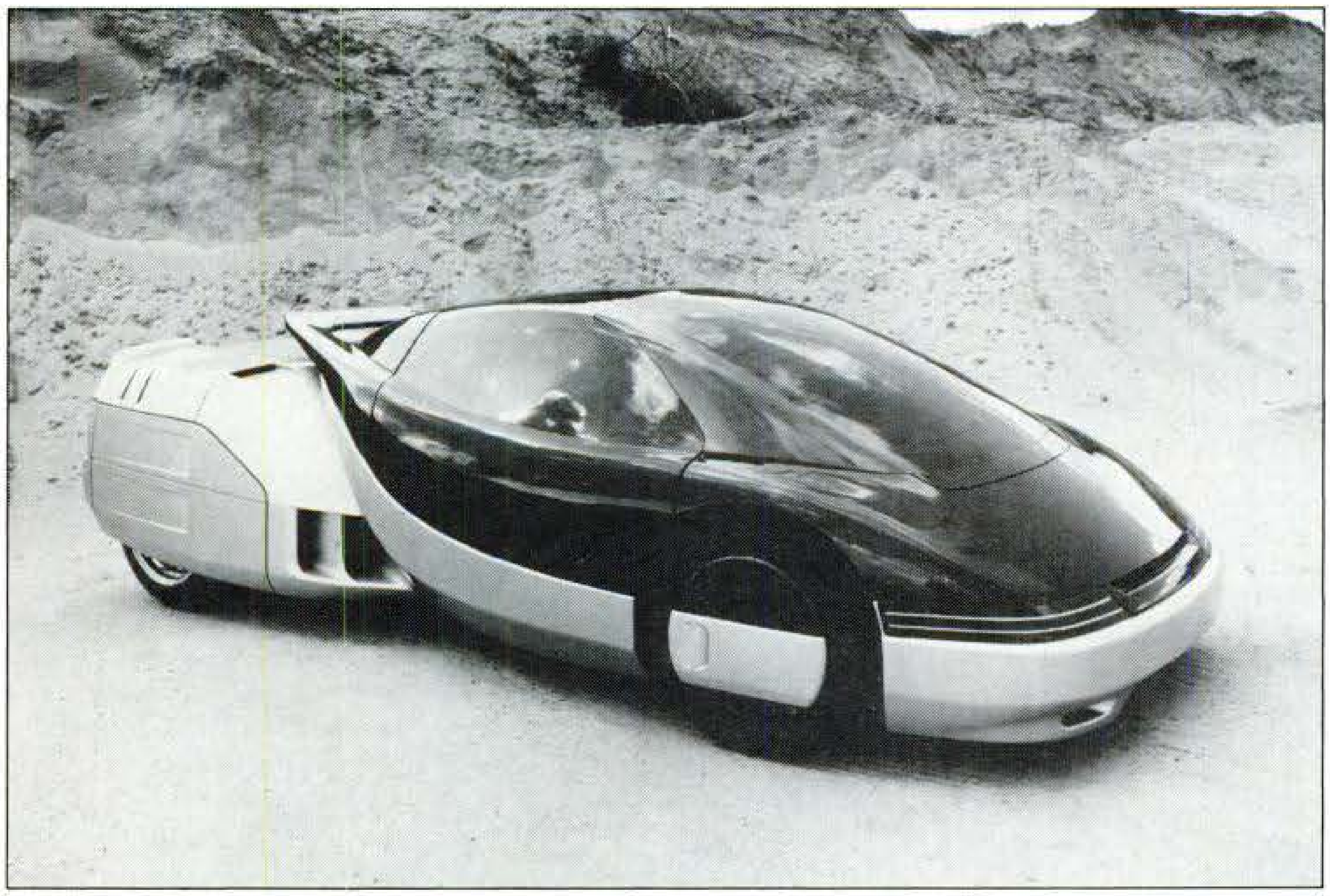
Use a flushing tee kit attached to a garden hose, and make sure the fresh flow goes through the heater core. Do this by putting the heater controls in the full-heat position. You may have to use a hand vacuum pump on the the vacuum line to the heater valve to get the valve open. Allow the entire system to flush for about 15 minutes, then drain it and refill with fresh coolant.

Unfortunately, I've found that flushing will rarely solve a serious cooling-system problem caused by long-term neglect. If the system is just rusty, use a chemical cleaner. For a badly clogged radiator, the only fix is to remove it and have it cleaned by a radiator shop.

Finally, to stay off the shoulder of the road or the business end of a wrecker, do a cooling-system check as part of your regular maintenance:

- Check the radiator for bugs and leaves.
- Check the radiator cap.
- Check the belts and hoses.
- Check the coolant recovery system.
- Check the electric radiator fan.
- Flush and refill the cooling system every two years. PS

Alien invades England



This British high-performance car earns its name—Alien—with its odd looks and contrasting pods for passengers and mechanical components. Created in secret by International Automotive Designhouse, and introduced at Italy's Turin Motor Show, Alien has a sleek, aerodynamic cockpit attached to a box-shaped power module. This wasp-waisted combination produces both low drag and high down force.

Under the bubble, futuristic controls and seating enhance the space-invader concept. Modeled after fighter planes, Alien's two-seat cockpit has a central handlebar with triggers for fingertip control of lights and other mechanisms. The driver steers with handgrips on the bar, which swivels 90 degrees to either side. The steering unit tilts up for clearance when the flip-up doors are raised via an infrared entry device.

The driver's semi-reclining seat adjusts relative to the handlebar assembly and pedals by pneumatically altering a matrix of air bags. The seats accommodate different body shapes and sizes, and the car stores a profile of each driver in its memory.

The instrument panel is a simple, flat-screen display. And the gear lever, mounted between the two seats, shifts back and forth in a straight line, like that of a motorcycle.

The rear module contains Alien's power train. The engine size can be varied by "plugging in" different power packs. The designers envision an economical four-cylinder engine for around-town use, while a second pack can be rented for extra power or for use during repairs. Even with larger engines, Alien is designed to limit power-train noise to the back pod.

The cooling system is also incorporated in the power module. Intercoolers and radiators feed through side intakes ducted with a venturi tunnel, helping keep the drag coefficient at a low 0.25.

Alien is just over 12 feet long and a bare 42 inches high. The car's chassis, made from aramid fiber and carbon fiber composites, has high body sills that form protective seat tubs. Supports for the gull-wing doors also shield occupants from impact.

With its safety features, IAD's car could be suited for many markets. Its inventors say the price of an Alien could compete with that of a typical front-engine Porsche. —*David Scott*

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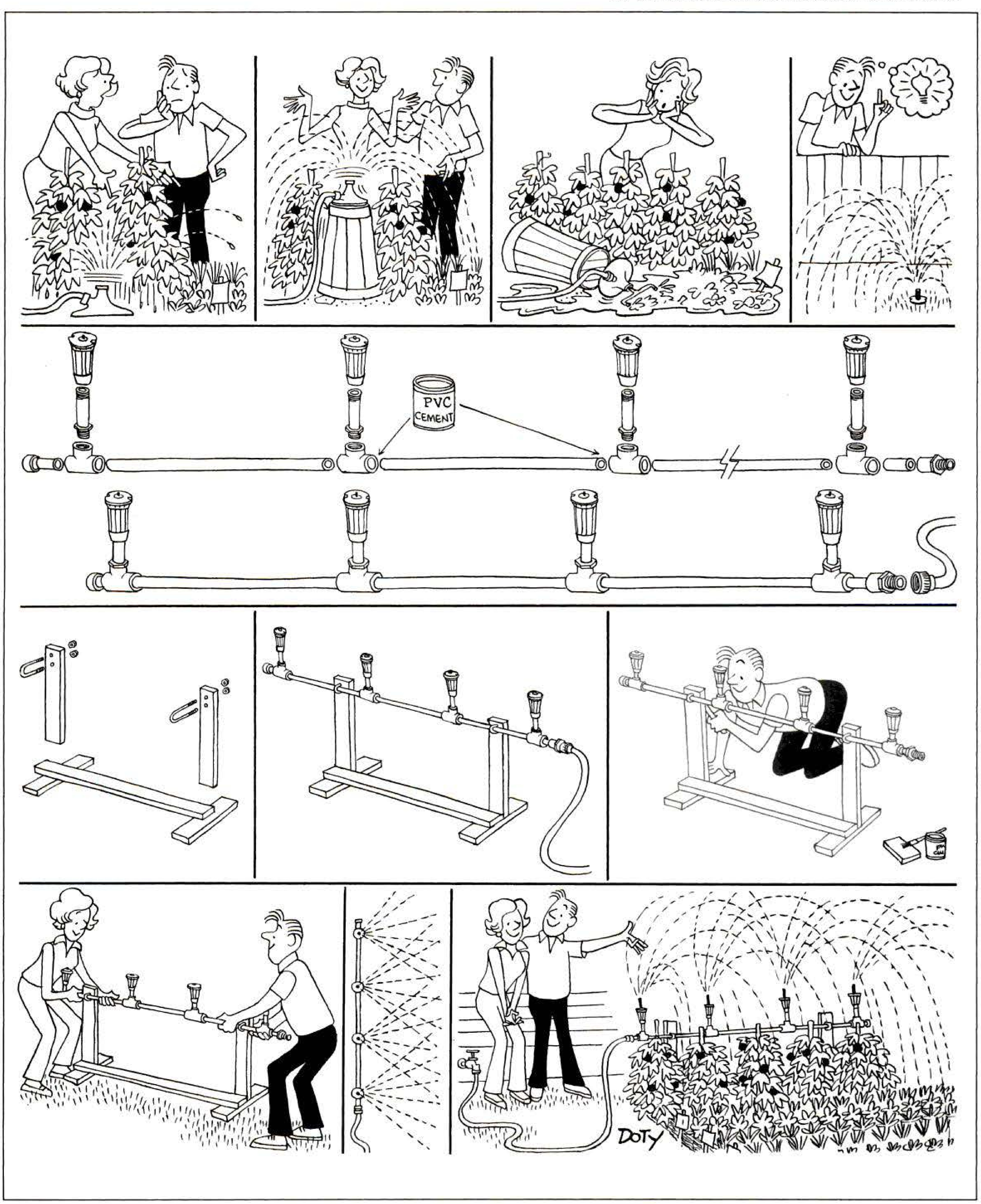

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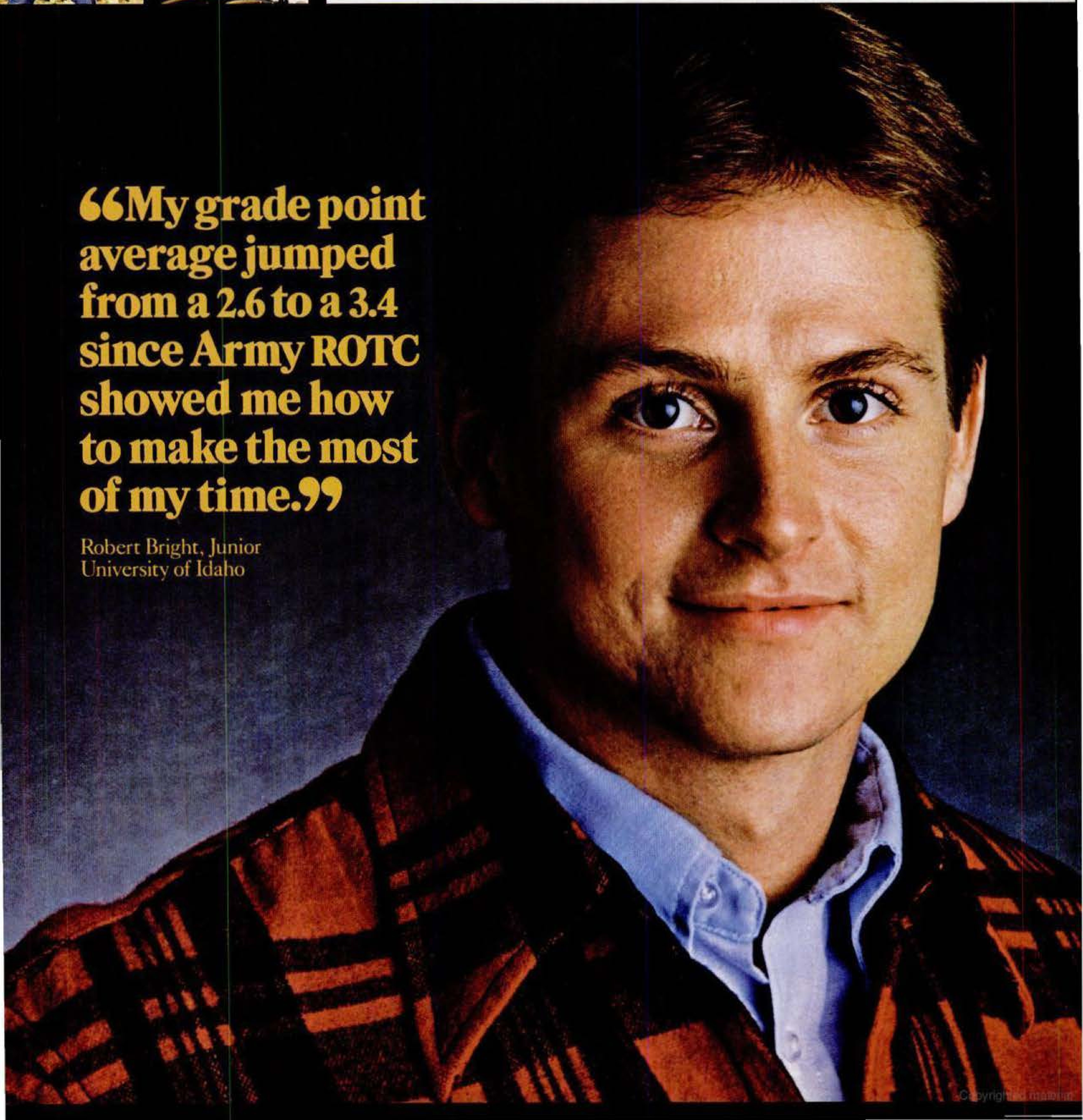

"My grade point average jumped from a 2.6 to a 3.4 since Army ROTC showed me how to make the most of my time."

Robert Bright, Junior
University of Idaho

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Winter's chill fights summer's swelter

The student recreation center at a large Southern university is cooled with well water that was exposed to the cool air last winter, then pumped back underground until summer rolled around. The system cuts cooling costs by one-third.

By ROBERT G. BEASON

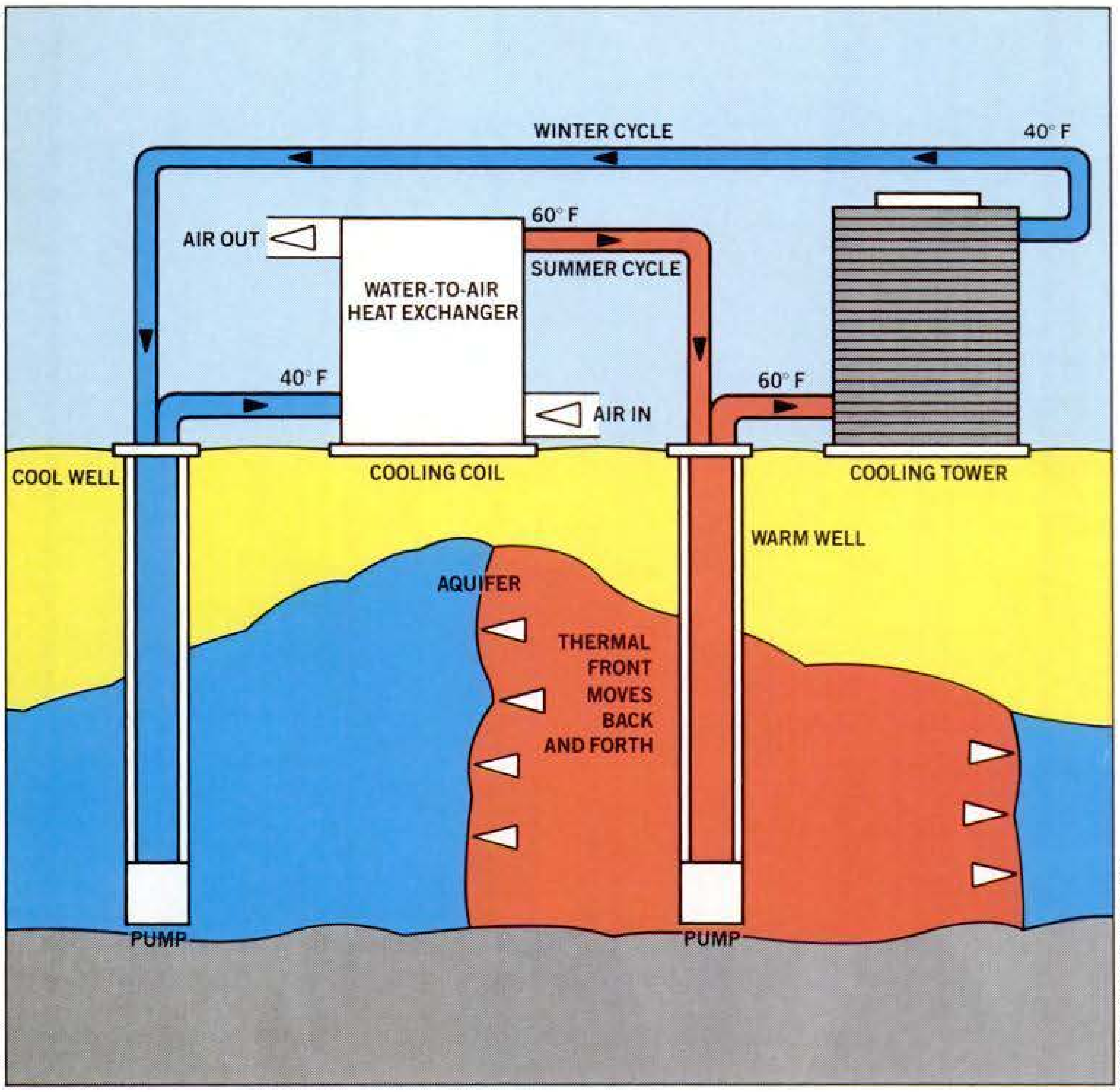
The idea of storing the chill of winter and using it to cool summer's heat is hardly new. Our grandfathers harvested January pond ice to cool their July tea.

Now the University of Alabama is applying the same principle to air conditioning. At the university's student recreation center in Tuscaloosa, winter-chilled underground water is drawn during the summer to supply the total cooling needs of the building. The concept, pioneered by two university scientists, Drs. Walter J. Schaetzle and C. Everett Brett, uses the underlying aquifer for literal cold storage.

"The system saves about thirty percent in energy costs over conventional air conditioning," says Schaetzle, "and it might eventually save seventy percent or even more."

Access to the aquifer, which begins about 40 feet down and is 50 to 60 feet thick, is provided by six wells in two rows. The wells are 150 feet apart; the rows, 250 feet apart (see drawing). Average well depth is around 110 feet.

"When winter temperatures fall below fifty degrees," explains Schaetzle, "water is pumped from one row of wells, cooled, and returned to earth at the second row." The cooler is a standard cooling tower such as those used atop office buildings. A blower speeds the nippy air through the tower as it takes up heat from the water. "The aquifer temperature here is around sixty-five degrees," he continues. "We bring it up and cool it, that's all." By winter's end the whole aquifer—some 15 million gallons of water—is down in the mid-40s.



DRAWING BY NINA WALLACE

In summer, when Tuscaloosa sizzles with temperature and humidity both frequently over 90, the now-cold water is once again brought up. This time it's put through a heat exchanger in the recreation center. "The building's air passes slowly through the exchanger and is kept at a constant seventy-four degrees," says Schaetzle. "The water, back to sixty degrees, is returned to the second row of wells. We just leave it there until the winter cooling cycle comes around again." Such thermal storage is highly efficient. "More than ninety percent of the cooling power put into the aquifer is recovered," claims Schaetzle.

Aquifers suitable for cold storage—those made up largely of pebbles and sand with little clay—underlie about 60 percent of the United States. Winter temperatures sufficiently cold abound everywhere except in Florida, Southern California, and Hawaii. Farther north, where winters are more severe, equipment for the cooling cycle can be simplified.

For your home?

"Original installation costs for aquifer air conditioning also are lower than those for a system using a compressor-type chiller," says Schaetzle. In Tuscaloosa, that amounts to about a 23-percent savings; farther north it would be more. Does that mean your home may be cooled by a future aquifer air conditioner? Not likely, unless you live in a truly grand house. Aquifer storage is practical only on a large scale, producing 150 to 200 tons or more of cooling capacity. The average home gets by on about three tons.

Besides the installation at the University of Alabama, the aquifer idea has been tried in a Tuscaloosa department store and in a Toronto building. There are about a dozen installations in China, Sweden, and Switzerland. "So far the only major difficulty to appear has been clogging due to sand and silt," says Schaetzle. "Filters and back-flushing have been used to solve this problem."

Though aquifer air conditioning is a wonderfully simple and economical concept, it, like space travel and cars at wholesale prices, remains an out-of-reach marvel for the average homeowner. PS

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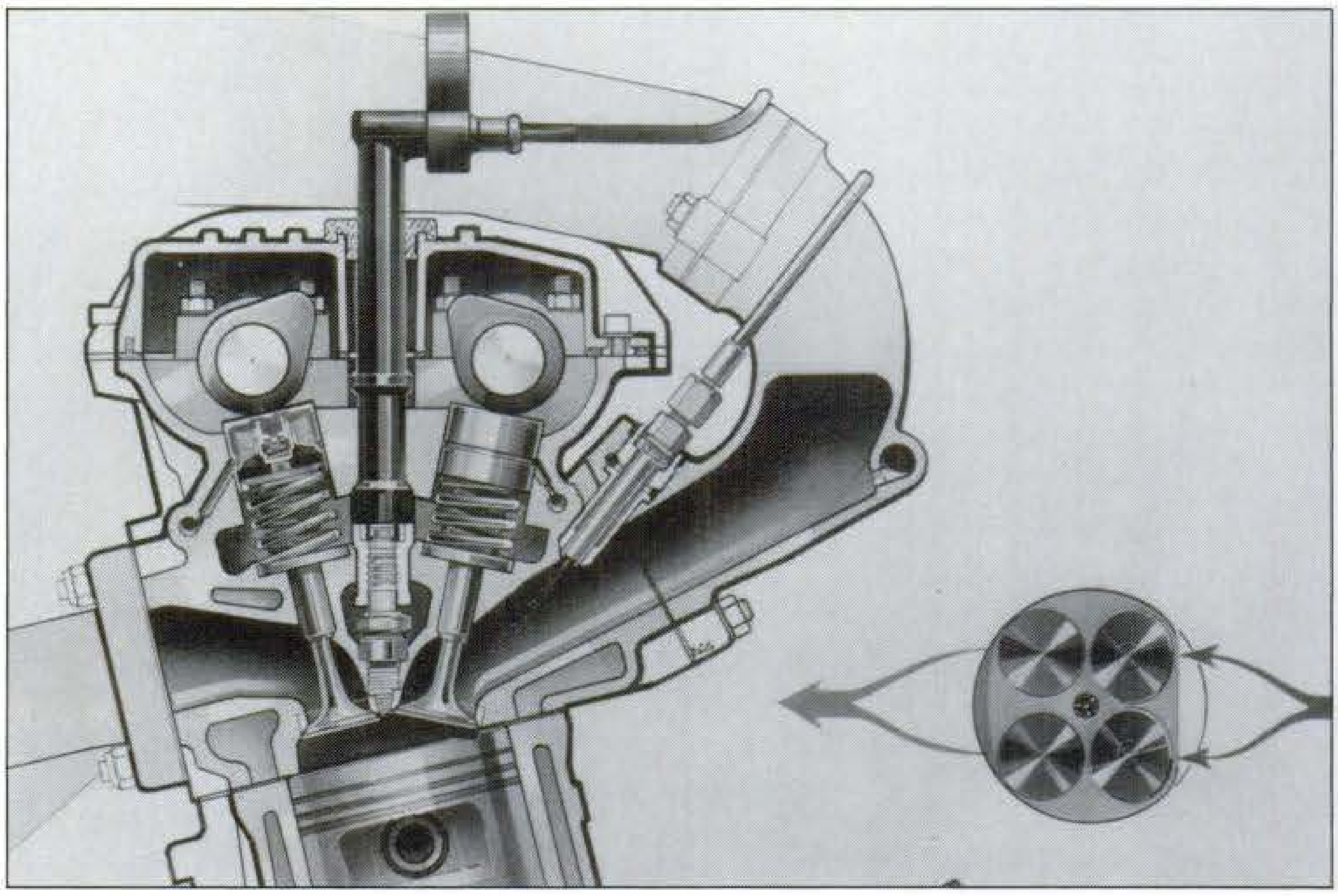
120-mph Scirocco



VW Scirocco's new cylinder head is a twin-cam cross-flow type. This enables the engine to inhale and exhale more easily. The result is extra power. Large smooth-radius runners from the intake manifold pack extra air into the cylinders. Hydraulic, instead of mechanical, valve tappets are fitted to ensure that the cams and valves retain their specific operating clearances.

The blazing Arizona sun blasted the too-hot-to-touch guard rail along the last turn at Phoenix International Raceway. Around me the asphalt shimmered silver with heat waves and the sharp scent of fried tire rubber and boiling hypoid oil hung in the dry wind. At that moment, I thought this hellish location was indeed perfect for introducing the 16-valve Scirocco—a car named after a desert wind, and one Volkswagen claims is the hottest U.S. car it's ever built.

The big change for the Scirocco is the 16-valve cylinder head and large, tuned aluminum-alloy intake manifold. Greater flow volume created by the multiple-valve arrangement, and intake air resonance and ram effect provided by the special manifold, combine to provide better cylinder filling. The result is a 37-percent increase in power—from 90 to 123 horsepower—from an engine with the same 1.8-liter displacement as the standard engine. VW says top speed for the standard Scirocco is 112 mph and its 0-to-60 time is 10 seconds flat.

I didn't have an opportunity to take the new car up to 122 mph—its claimed top speed—but I did do several 0-to-60 runs. VW says the 16-valve takes 8.15 seconds to 60 mph. I did three runs to 60 in 8.0 seconds with a passenger. To slow the speedier Scirocco, VW has fitted large disc brakes on all four corners. These are easily modulated, and stop the car with arresting cable-like power. Price: $11,980.—*Jack Keebler*

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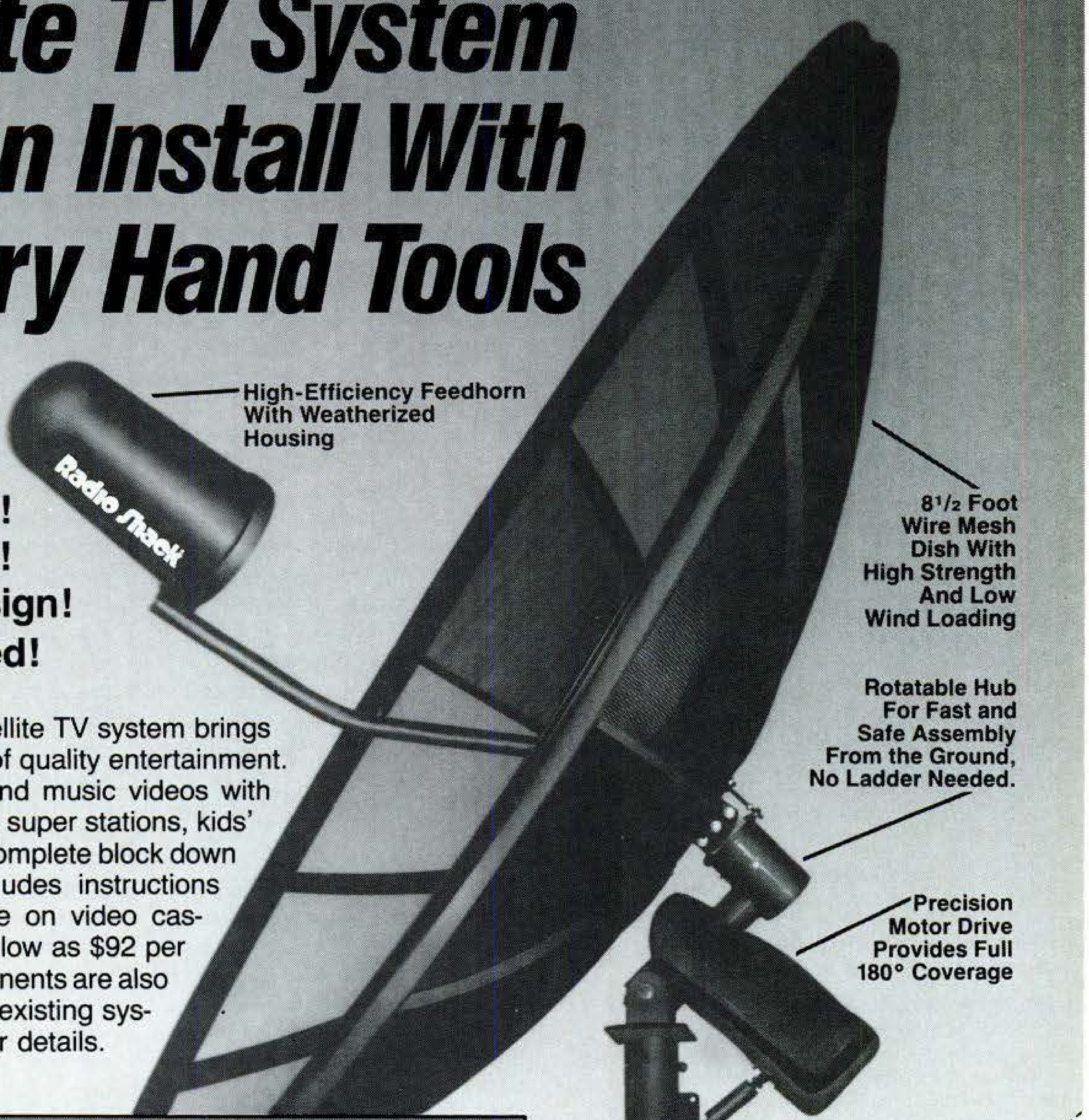
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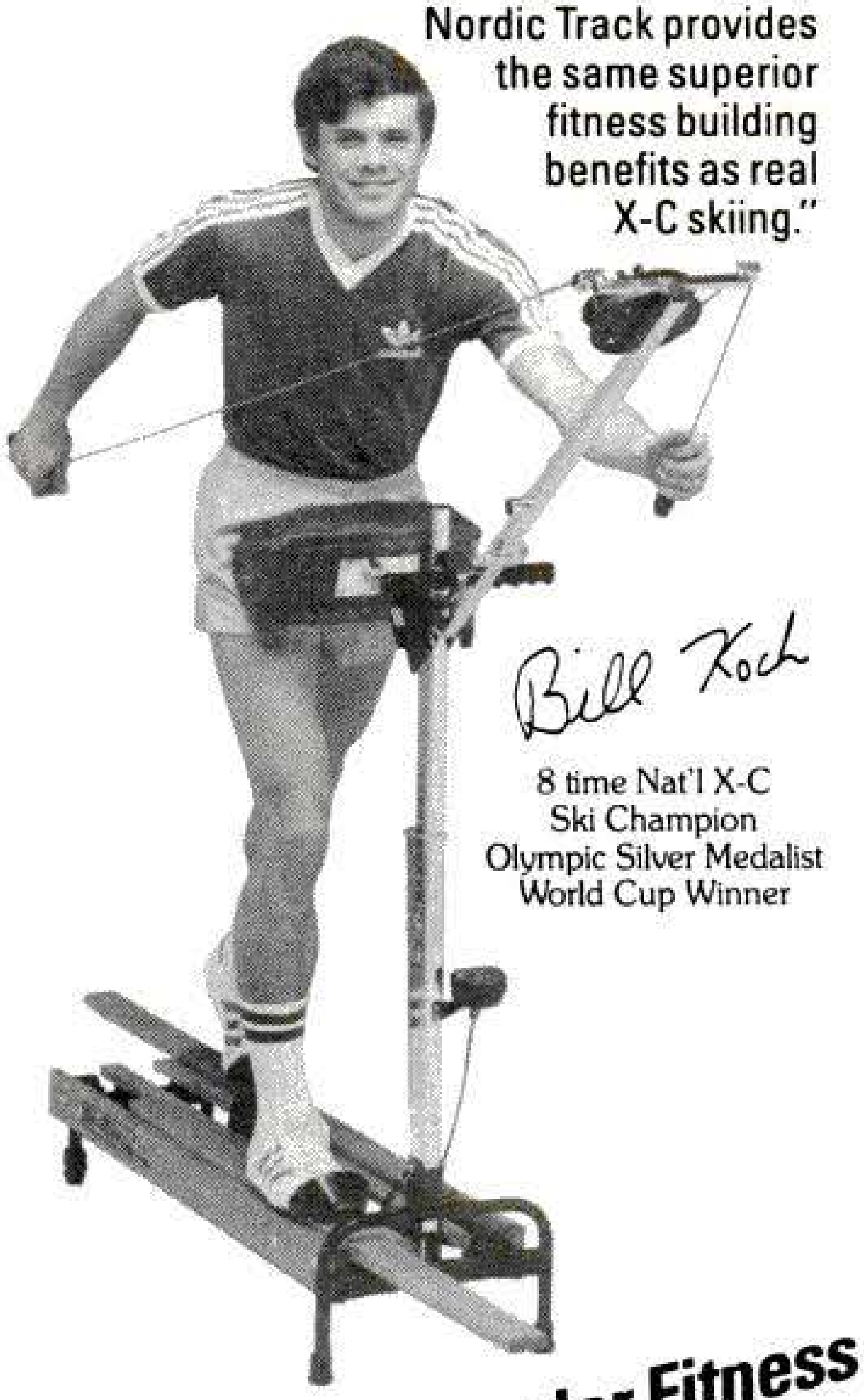

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Foiling the summer sun

[*Continued from page 74*]

Before you can see how radiant-barrier systems operate, Fairey says, you must understand the three modes of heat transfer: convection, conduction, and radiation (see heat-transfer illustration, right). Mass insulation stops heat transfer by *conduction*, whereas radiant barriers impede *radiative* heat transfer, an entirely different mechanism.

On a summer day in a sunny climate, Fairey explains, a roof may be as much as 100 degrees F hotter than the air temperature because it's absorbing radiant energy. Once that radiant energy is absorbed by the roof surface, it's got to go somewhere. Most of the heat convects into the outside air, but some of it conducts down through the roof materials and radiates across the attic space to the cooler surfaces that face the underside of the roof (often, standard fiberglass ceiling insulation). From there, it conducts to the living space below.

A foil barrier stops that radiative heat transfer, Fairey says. The reason? Low-emissivity aluminum foil reflects radiant heat well, and doesn't emit radiant energy well. As long as the foil faces an air space, it stops the thermal radiation emitted by the roof. In fact, when it's matched up with an air space, a radiant-barrier system can stop 95 percent of the thermal radiation across an attic air space, Fairey says.

What's available?

There are many kinds of radiant barriers on the market, the FSRC scientist noted, as he showed me several samples. Builder's foil has one or two foil sides, usually reinforced by kraft paper. Other types are fiber-reinforced or backed with plastic to make the foil less apt to tear and easier to handle. Some foil products have more than one layer, Fairey says, but because the first foil layer stops almost all of the incoming thermal radiation, multiple layers may not be necessary. Fairey adds that foil-faced insulation products have only to face an air space to function as radiant-barrier systems. These products may be more expensive than other options, he says, but they also impede conductive heat transfer.

In most warm climates, radiant barriers are effective and economical in attic spaces, Fairey says. Research at FSRC, he notes, indicates that radiant barriers can cut air-conditioning costs by as much as 10 to 12 percent in Southern homes with R-19-insulated roofs. FSRC also estimates that radiant barriers can be excellent energy savers in homes as far north as Baltimore. Material and installation costs are so low that energy savings can often pay for the barrier system in just a few years.

Putting up a barrier

Radiant barriers are relatively easy to install during new construction, and, in homes with pitched roofs, they're not overly difficult to retrofit.

To install a barrier system in new construction, drape the foil face down over roof trusses, and then apply the plywood over the ribs. Wind can be a problem, so a jig that operates like a large movable paper-towel dispenser can help you handle the rolls.

If you've already applied the plywood decking or are retrofitting, cut the foil to length beforehand, Fairey suggests. Then staple the radiant barriers to the underside of rafters. You can also fasten the barrier directly to the decking or to the bottom of the top chord, he notes. A less favored, but simple, installation option is to place perforated foil face up on the ceiling insulation. "Unfortunately," Fairey said, "dust will accumulate on the upper surface, which will absorb and pass on the thermal radiation you're trying to stop."

A combination of continuous soffit and ridge vents is the best way to vent the attic, Fairey advises. "Stop the radiant barrier about an inch or two before you reach the peak, because this maintains ventilation of roof area and general attic space. Be sure," he added, "that the radiant barrier extends as close to the soffit as possible. An easy method to get the radiant barrier into tight eave areas is to slide a piece of foil-faced construction sheeting between the rafters and down to the soffit.

"Remember that small gaps will not make a big difference in the system's operation. Radiation travels in a straight line, so small holes will allow very little to pass through," Fairey said.

Cathedral ceilings are a problem (see attic illustration). "There's a limited amount of space between rafters," Fairey said, "but the air spaces can be quite small, so it's possible to have both radiant barriers and mineral insulation in a cathedral ceiling." In very hot climates, he says, the system's performance will be improved by venting the air space at the soffit and at the roof peak to cool the roof decking.

The big remaining question: Do radiant barriers stop heat gain in winter? "They'll stop daytime heat gain," Fairey said, "but they'll also retard nighttime heat loss. In total, this phenomenon should slightly reduce heating costs." Fairey stresses that more study is needed in this area. PS

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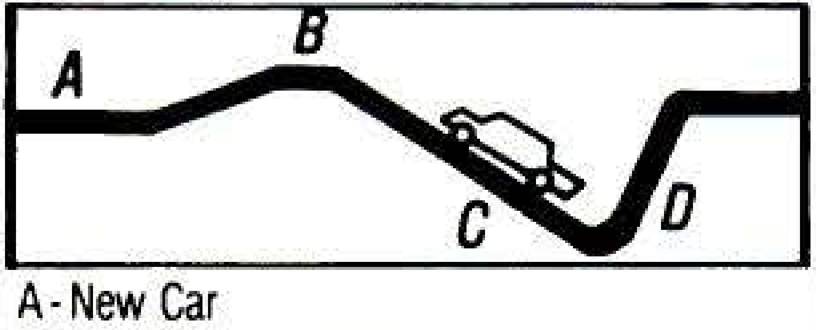

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[Continued from page 82]

What about 8-mm video recorders used for digital audio recording ["New Tiny Camcorders," PS, Sept. '85]? "Eight-millimeter is no real competitor to the R-DAT system," says Matsushita's Clegg. "While they can record digital audio for up to twenty-four hours on a tape, the audio quality is not anywhere near as good as what R-DAT will offer."

The digital sampling rate used in 8-mm recorders is only 31.5 kilohertz (R-DAT is 48 kHz). This limits the high-frequency response to just 15 kHz. "That's adequate for video and broadcast applications," says Clegg, "but I don't think that audiophiles looking for the ultimate in audio quality will settle for such a restricted bandwidth."

One disappointment

Every audio buff has this dream: to make a perfect reproduction of a CD or prerecorded digital tape by copying its digital code. Such direct digital-to-digital recordings would preclude any degradation of audio quality that might be caused by the usual analog conversion. If that's what you were hoping for, you're out of luck.

To prevent pirating of copyrighted music, the EIAJ committee chose a recording sampling rate of 48 kHz for DATs. Because CDs use a 44.1-kHz sampling rate, the digital signals are completely different. Of course, you will be able to copy your own digital tape recordings, but prerecorded tapes (which are likely to be available once DATs are in widespread use) will be recorded at 44.1 kHz. The DAT's electronics will switch to the lower sampling rate and play the tape, but a second DAT will not be able to record the signal.

Performance of these new digital machines will be awesome: They'll have a dynamic range of at least 90 dB; frequency response from below 10 Hz to better than 20 kHz (when the 48-kHz sampling rate is used); absolutely no wow and flutter (wavering of pitch that's common to inexpensive analog cassette recorders); and distortion so low that it's unmeasurable.

Price? Onkyo's Birch-Jones says about $1,000. That's high, but if the short history of CD players and VCRs is any indication, the price of DATs will quickly drop once the machines become popular. When that will be—at present—is anybody's guess. But considering the advantages of DATs over conventional recorders, the future looks bright. "We hope to be the first to offer a home DAT," says Onkyo's Birch-Jones. "But we're sure it won't be long before every major audio company introduces its own model." PS

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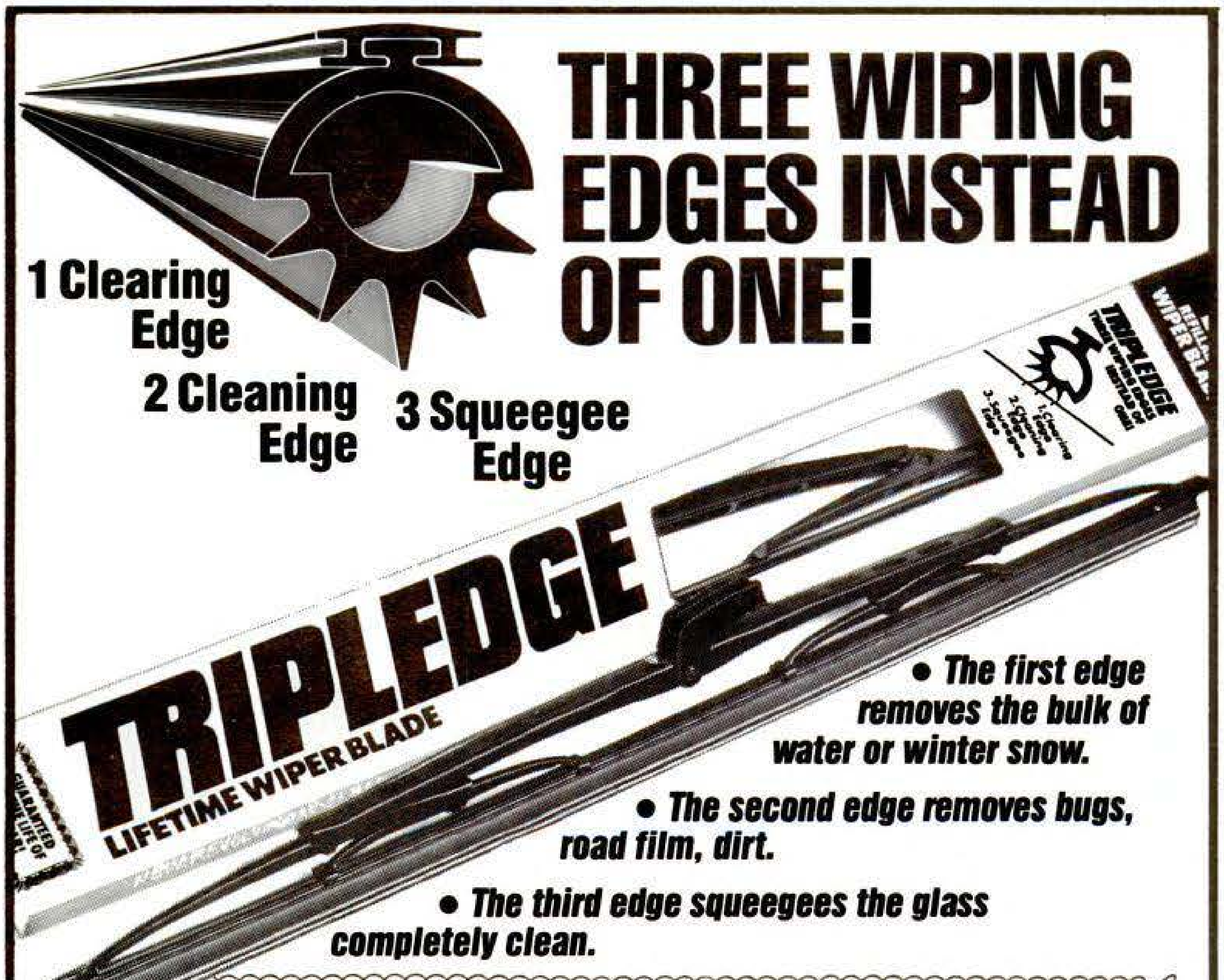

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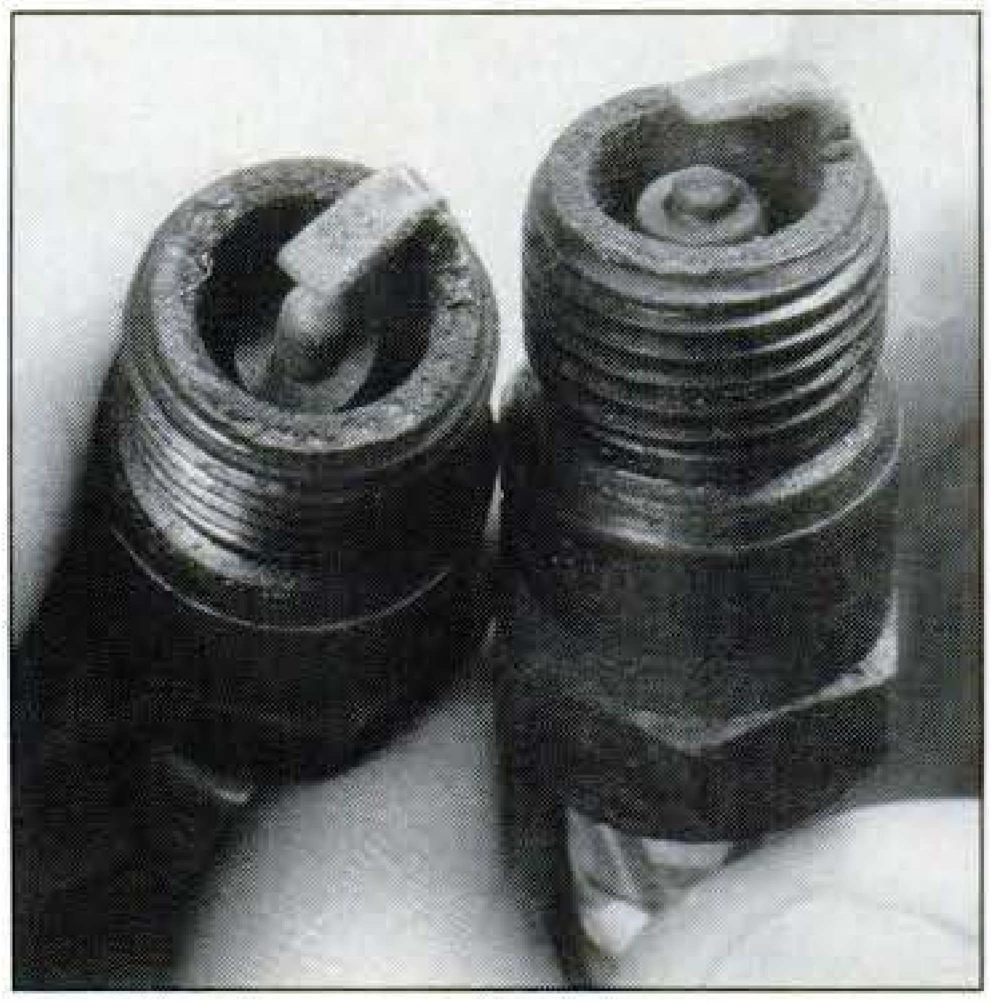

I once read in your column that you couldn't go 65,000 miles on a set of spark plugs. (Someone wrote and said that they had.) I drove my 1978 Chevy Step Van with the 350-cubic-inch engine 103,000 miles before the spark plugs misfired. This is what they look like [photo].

Howard G. Newcombe
Myrtle Creek, Ore.

Well, you won the battle, but I think you lost the war. I suppose it's possible under ideal conditions to go even farther on original spark plugs, but I'm sure this is more expensive than changing them when their condition warrants it.

Here's the way I see it: Gas mileage and spark-plug condition go hand in hand. As the electrodes erode and become contaminated (spark plug on right above), the gap begins to change, affecting ignition timing. And as the ceramic insulator (left) starts to break down, it leaks current. Both of these conditions make fuel mileage worse. Then, when the plugs get really bad, they start to misfire under heavy load or hard acceleration, further reducing efficiency. The battery and starter system also pay a toll, because the worn plugs make the engine harder to start.

Noisy belts

My 1976 Dodge Aspen developed a clatter in the engine compartment. I replaced the water pump twice, the fuel pump, and the alternator. I also tightened the belts. No success. Then a mechanic solved the problem by spraying the fan belts with belt dressing. How can a fan belt problem cause such a clattering noise?

Paul A. Stough, Scottsdale, Ariz.

When a V-belt gets too worn or contaminated with oil or grease, its sides become glazed and cracked. If the sides of the belt wear at odd angles, it will begin to bottom out in the pulley, slip, and get noisy. Belt dressing is a quick fix, not a solution.

If a belt won't do its job when it is adjusted to the proper tension, it's time for a new one. V-belts should be routinely changed every two years, or sooner if their condition warrants it.

Gas or diesel?

My wife and I are considering the purchase of a 25- to 27-foot Class-A motor home. Most of these vehicles come with either the 454 Chevy, 440 Dodge, or 460 Ford engine. From the standpoint of fuel economy, I think that I would like a diesel engine like the Ford (International) 6.9-liter engine. However, because we will be in the western mountains quite a bit, I have doubts about the hill-climbing ability of this engine. What do you recommend?

Leo Wingate Jr., Covington, Tenn.

I think gasoline engines are usually a better choice because they have more power; motor homes are heavy and have to push a lot of air out of the way. As a rule, motor homes don't get a lot of mileage put on them. With the relatively high price of diesel fuel now, the cost saving over a gas engine isn't so great. If you do plan to drive a lot of miles and want a diesel for its better mileage and reduced service needs, make sure you get one with adequate horsepower. Diesels generally have enough pulling power to climb hills, but often can't deliver the road speed you want for long-distance cruising.

Sluggish front-drive

My car is a 1981 Plymouth Reliant with a Mitsubishi 2.6-liter engine. The engine has been sluggish since new and now has 40,000 miles of use. Too-tight distributor advance springs have

Continued

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"Say, Smokey—"

Continued

been corrected, and ignition timing, accelerator pump, and idle-mixture settings have all been adjusted. The car also has new air and gas filters, and a clean gas tank and fuel lines. I'm told that this car is supposed to be peppy, but it can barely get out of its own shadow.

Joseph Collins, Richardson, Texas

First, check for a bad torque converter in the transmission; it may have a failed stator. Maybe you need to look at Chrysler service bulletin 14-05-84 regarding correcting a primary-jet block for a little more fuel flow. Check the exhaust-gas recirculation [EGR] system for too much EGR. Also, make sure the throttle linkage permits full throttle opening.

Intermittent rough running

I have a 1984 Mercury Marquis with a V6 fuel-injection engine. While driving on the highway at 55 to 60 mph, the car will backfire and run very rough for five to seven miles, then clear up and run well for another several days. The problem will then reappear. The dealer has connected his computer to the car's "brain" four times and found nothing wrong.

Jack A. Measley Jr., Saline, Mich.

Backfiring is caused by a cylinder firing when the exhaust valve is open. There are two reasons this can occur: 1) A cracked distributor cap, bad plug wire (or wires), or malfunctioning ignition-control electronics are allowing current to reach a spark plug at the wrong time; 2) an exhaust valve is sticking open or a camshaft lobe is damaged.

Goo in the air cleaner

An emulsion of oil and water collects in the bottom of the air cleaner in my 1983 Dodge Aries with the 2.2-liter engine. A mechanic said this condition can be corrected by a new PCV valve that's available, but he doesn't have it in stock. Is he correct?

Fred C. Trager, Barberton, Ohio

Your mechanic is right. Using a higher-flow PCV valve (part No. 521 4088) will solve the problem. The valve in your engine is too small. Service bulletin 14-55-84, issued on Dec. 21, 1984, explains the whole story.

Got a car problem? Send it to "Say, Smokey—," POPULAR SCIENCE, 380 Madison Ave., New York, N.Y. 10017. All letters are read, and those of widest interest are answered in this column. Due to the large volume of mail, Smokey cannot reply to letters not selected for publication.

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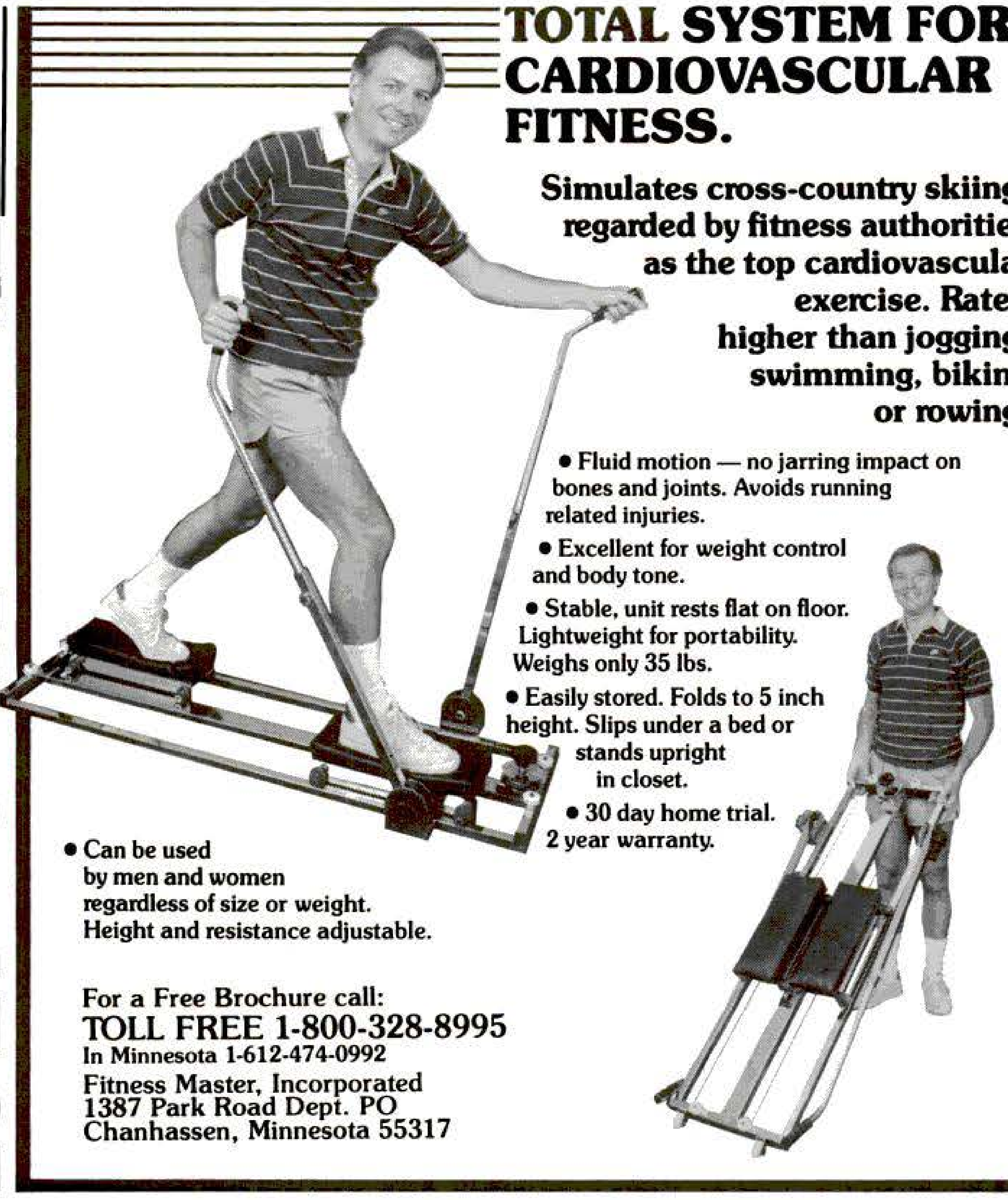

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QUIT YOUR JOB or START PART-TIME.
Chimney Sweeps Are Urgently Needed Now!

My name is Tom Risch. I'm going to show you how to make $200.00 a day saving people from dangerous chimney fires.

This is serious business. People are paying $55.00 to have their chimneys cleaned, and the average sweep completes the job in less than an hour. You can make $200 a day part-time—$1,000 or more a week full-time. Now before you turn the page, let me explain.

Tens of millions of people are burning wood to supplement the high cost of oil, gas, and electric heat. There are now over 50 million woodburning chimneys in the U.S.—an increase of 10 million in only one year.

As a result, an estimated 44,000 chimney fires killed almost 1,000 people last year and destroyed over 180 million dollars in property.

Thousands of chimney sweeps are needed now.

Time Bomb In Your Chimney

A dirty chimney with about a quarter inch of soot contains a highly flammable substance called Creosote. If a spark from your fireplace or woodstove ignites the creosote in your chimney—watch out! The draft gets stronger and stronger, and before you know it, the entire inside of the chimney catches on fire.

As the fire grows in your chimney, the draft also increases to a tremendous velocity. The heat, generated from the draft and the burning creosote reaches a temperature of up to 3,000° F which is hot enough to melt the mortar holding the bricks together. Secondly, small flaming balls of creosote loosen from the side of the chimney and are projected out of the top with the force of a jet engine.

Like a roman candle, these flaming creosote balls shower the area. Some land on your roof, on your lawn and on your neighbor's home. The excessive heat of the chimney can catch the wood framing of your house on fire.

The only way to avoid a disaster like this is to clean the chimney before it catches fire. This is where you come in.

Chimney Sweeping

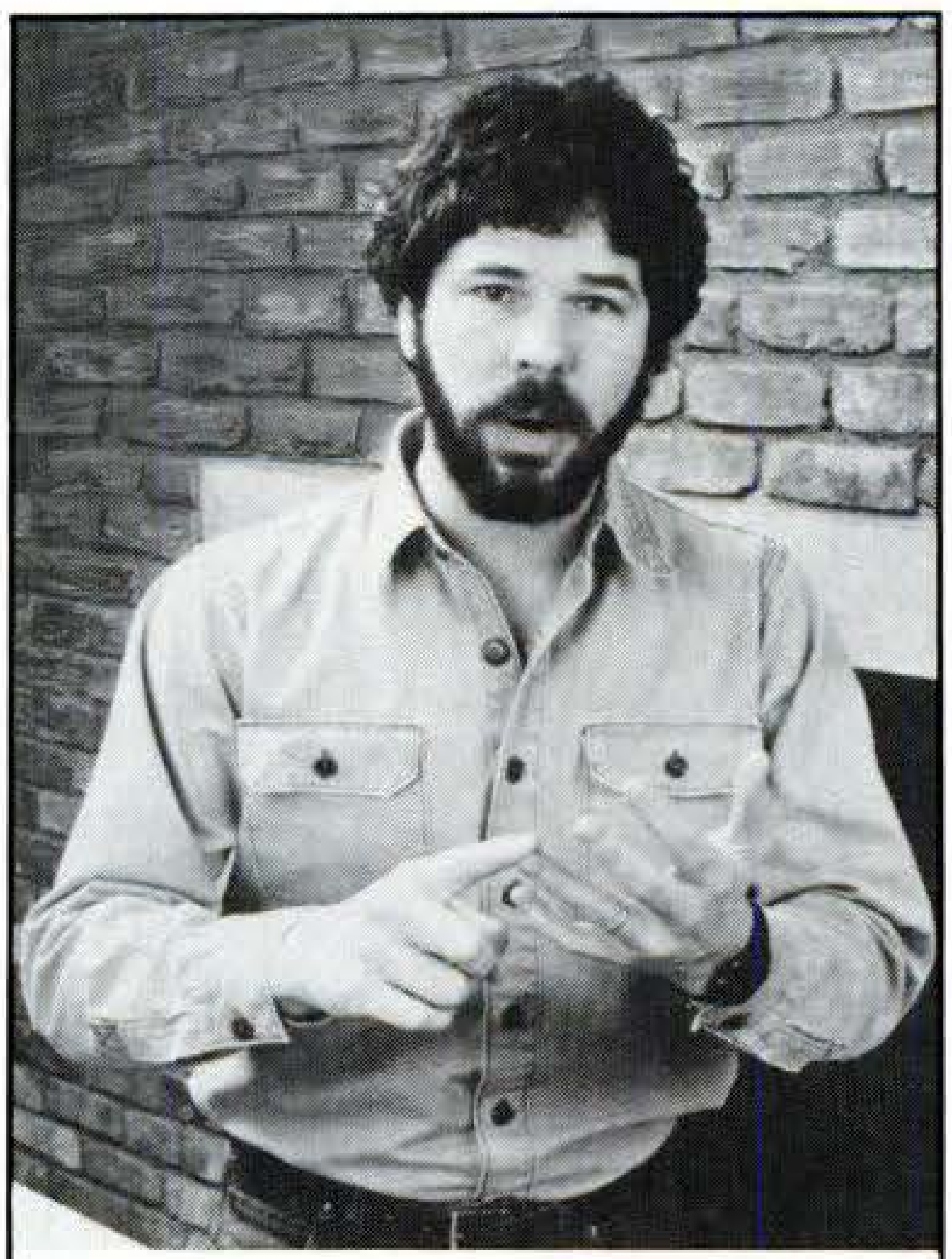
Here's a new business where you can earn more in one hour than most jobs pay for a whole day. More in one week than a lot of people make in an entire month. You're the boss. You set the hours and best of all, it's fun. You'll work your tail off, but the business will be your baby. I've had people tell me that the August West Chimney Cleaning System literally changed their lives. Not just because of the money they are making or the fact that they use more Ivory soap, but mainly because they are motivated. They're doing their own thing and loving it.

How Much Money?

Recently I telephoned some of the people we helped get started in the chimney cleaning business. I wanted to find out—first hand—just how well they were doing. Here's what a couple of them said....

Dave Richison, Ohio

"The 3rd quarter of this year I did $23,000. The 4th quarter I did $24,000. We should hit between 55 and 60 thousand this year."



"Home heating is now the number one cause of residential fires. Eighty-six percent of wood heat related fires originate in the chimney. The demand for qualified chimney sweeps is skyrocketing and now is the time to get started," says Tom Risch, Founder of August West Systems, Inc.

Chris Nestor, Massachusetts

"My first day on the job, I cleaned seven fireplaces. Now, after sweeping over 8,000 flues, I still look forward to going to 'work' every morning — six days a week, all year round."

John Moszulski, Canada

"Last month I worked 18 days, and I made 2,600 bucks!"

Ed & Mo Simonson, Texas

"We're very pleased with it. We're making a dream come true. We've always wanted some land, and thanks to chimney sweeping we now own 30 acres."

Just what do these people do to earn that kind of money? Sweep chimneys. Six to eight a day if they're full-time. Two to three an evening, plus ten or so on the weekends for those part-timers who keep their present jobs. Since the average charge is $55 for the first and $45 for each additional in the same house, it's easy to see how John Moszulski made $2,600.00 in 18 days!

The Height of Technology

How do you clean a chimney? You do it as quickly and efficiently as possible. The more chimneys you can clean in a day the more lives and loss of property you'll save. And how do you do a good job in record time? You use the most advanced system available—The August West System.

One of the key elements in the August West System is the SootSweeper. This machine is a high-powered, high-volume dust collection unit that was designed specifically for cleaning chimneys. New filter technology is the key to its efficiency and dependability.

Other key elements of our system are an assortment of high carbon steel brushes, specially designed fiberglass cleaning rods (that let you do most jobs from below), an easy-to-follow handbook with everything from advertising to chimney design, a bi-monthly newsletter, telephone consultation and much, much more. I don't have room to go into all the details right now. Our information kit will explain everything to you.

10 Years of Dependable Service

I'd just like to say that many years and a tremendous amount of devotion have gone into the development of the August West System. We are a strong, national company with thousands of dedicated sweeps in our network! You can join us and count on us to help you build a business you can be proud of. We take pride in the quality of our equipment and service to you.

Sweep John Moszulski says, "Not only do I think your System is fantastic, but I am also totally impressed by the way you treat people who have bought your System. I have just finished my third $1000 week—on a part-time basis."

To Sum Up, Then...

Sweeping chimneys may not exactly be a "Lazy man's way to riches"... you'll work hard—but the pay is exceptional, the demand is steadily growing, and new equipment and methods make the job far easier, faster and safer than ever before. Perhaps best of all, this is one of those "dream" businesses that so many of us are always looking for: a cash business with flexible hours, low overhead and a reasonable start up cost—figure about $1900 to get started.

And don't forget, when you run a small business out of your home, you can take tax deductions for that portion of your home you use for your office and work area, as well as car payments, phone bills, utilities and anything else you use in business.

As a matter of fact a lot of sweeps pay for their system in tax savings alone.

FREE Information Kit

Find out more about what it's like to be a chimney sweep cleaning 25 chimneys or more a week. Just call TOLL-FREE 800-225-4016 and ask for extension 484. I'll rush you a detailed information kit with the complete August West Story and your 33⅓ RPM record entitled, "Now Hear It From The Sweeps." We urge you to call us at no obligation, TODAY.

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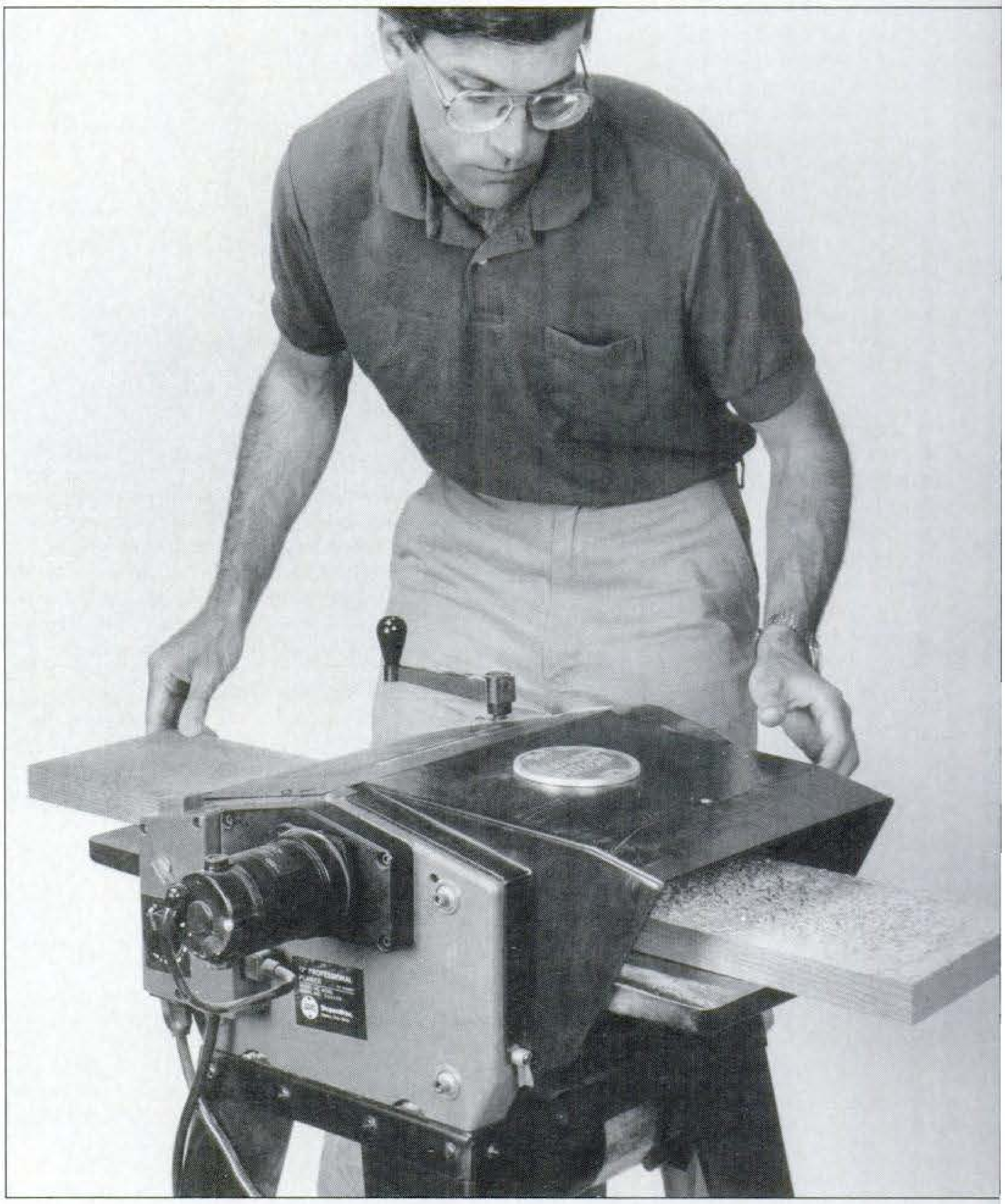

corners

Shopsmith's beefed-up planer now has its own motor and four legs to stand on.

By A. J. HAND

A few years back I tested the Shopsmith 12-inch Thickness Planer for POPULAR SCIENCE and was impressed with the tool. But a few months ago I gave it away. The reason? I replaced it with Shopsmith's new Professional Thickness Planer. The pro model does superb work like the original [PS, Sept. '83], and boasts a few significant improvements.

My original planer came as an accessory, powered by the Shopsmith Mark V power head. This setup worked so well, I soon found myself using the Shopsmith for little else. The new planer ($999) is autonomous; it comes with its own stand and a 1¾-horsepower motor. It has some heavy-duty refinements as well:

- A heavy cast-iron table instead of a lightweight aluminum bed. This gives the tool more mass for smoother cutting.
- A knurled steel infeed roller and rubber-covered outfeed roller. The original had rubber-covered rollers for both feeds. I found they tended to slip on heavy cuts if not cleaned of dust regularly. The knurled steel roller solves that problem.
- Maximum cutting depth of ⅛ inch (increased from 3/32 inch). Maximum stock capacity remains at 12 inches wide by six inches thick.

I have one minor complaint: When you make a light final cut, the planer won't cut deeply enough to remove the knurl marks pressed into the wood by the steel roller. This is mostly a problem on narrow stock; on boards over four or five inches wide, it's less pronounced. PS

Shopsmith's 12-in. Professional Planer (top) is a stand-alone unit. Controls (far left) are clustered at the right front corner of machine. The scale at far left reads thickness; a dial controls the feed rate; and the power switch is between the two. A knurled steel infeed roller (left) grips the stock firmly.

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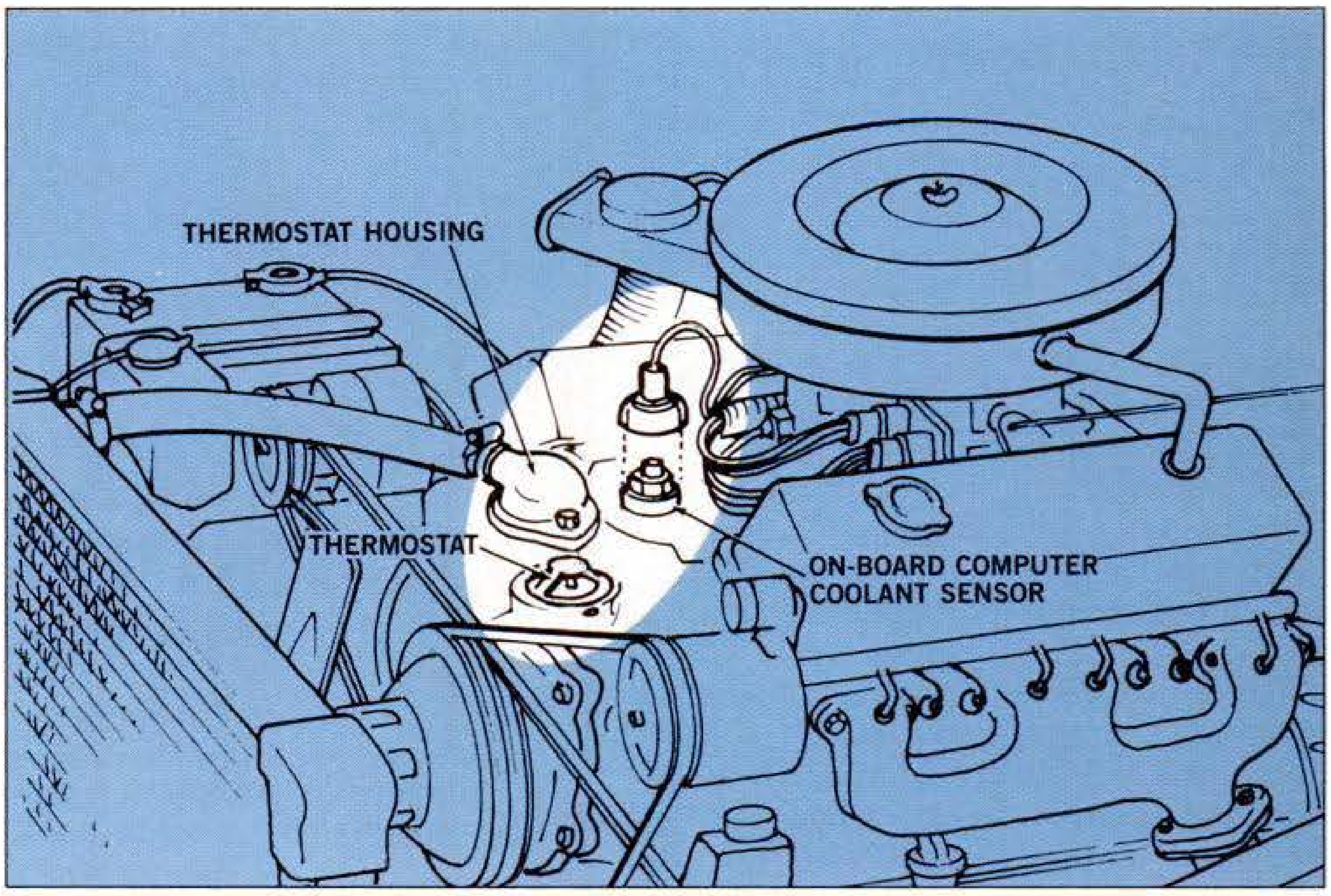
Taking Care of Your Car

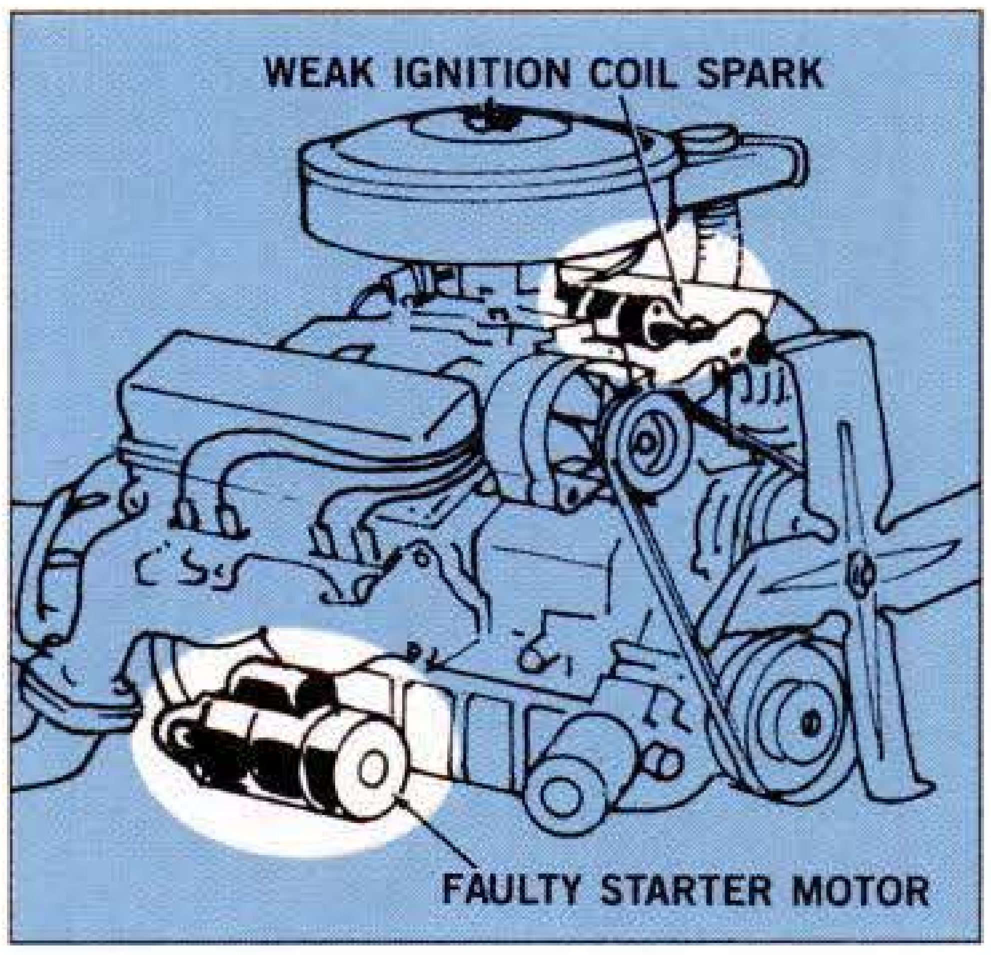
By STEVE MERCALDO

Got a useful car tip? Send it (with Social Security No.) to Car Care, Popular Science, 380 Madison Ave., New York, N.Y. 10017. We'll pay $50 if we use it. If two or more readers send the same tip, payment goes to the one with earliest postmark. No tips can be returned.



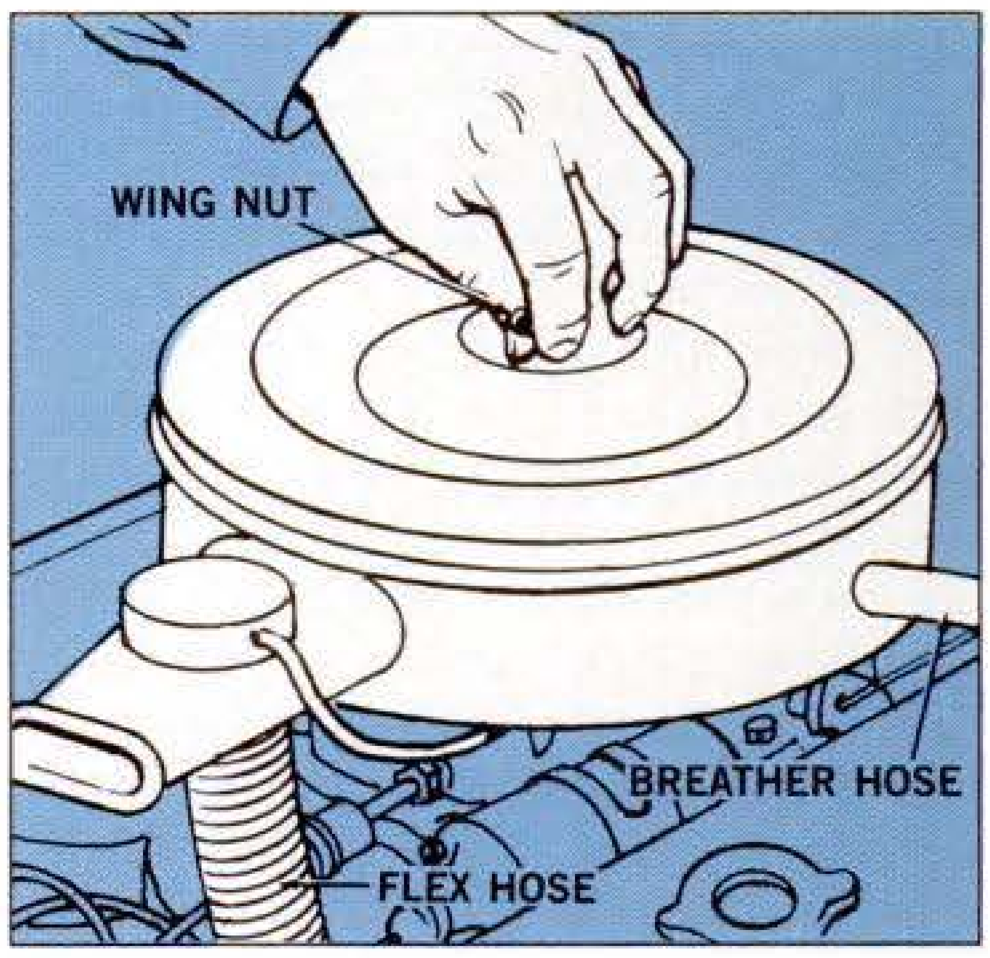
Faulty coolant sensor robs power

Have you noticed a drop in both fuel economy and power from your engine? The problem could be a malfunctioning coolant thermostat. Newer computer-controlled engines use a special coolant temperature sensor. When the engine warms to normal operating temperature, the signal from the sensor triggers a computer program that monitors fuel mixture, timing, idle speed, and other functions. A faulty thermostat can delay this signal or stop it from being sent. The engine then operates in the open-loop, or limp-home, mode, resulting in reduced power and poor fuel efficiency.



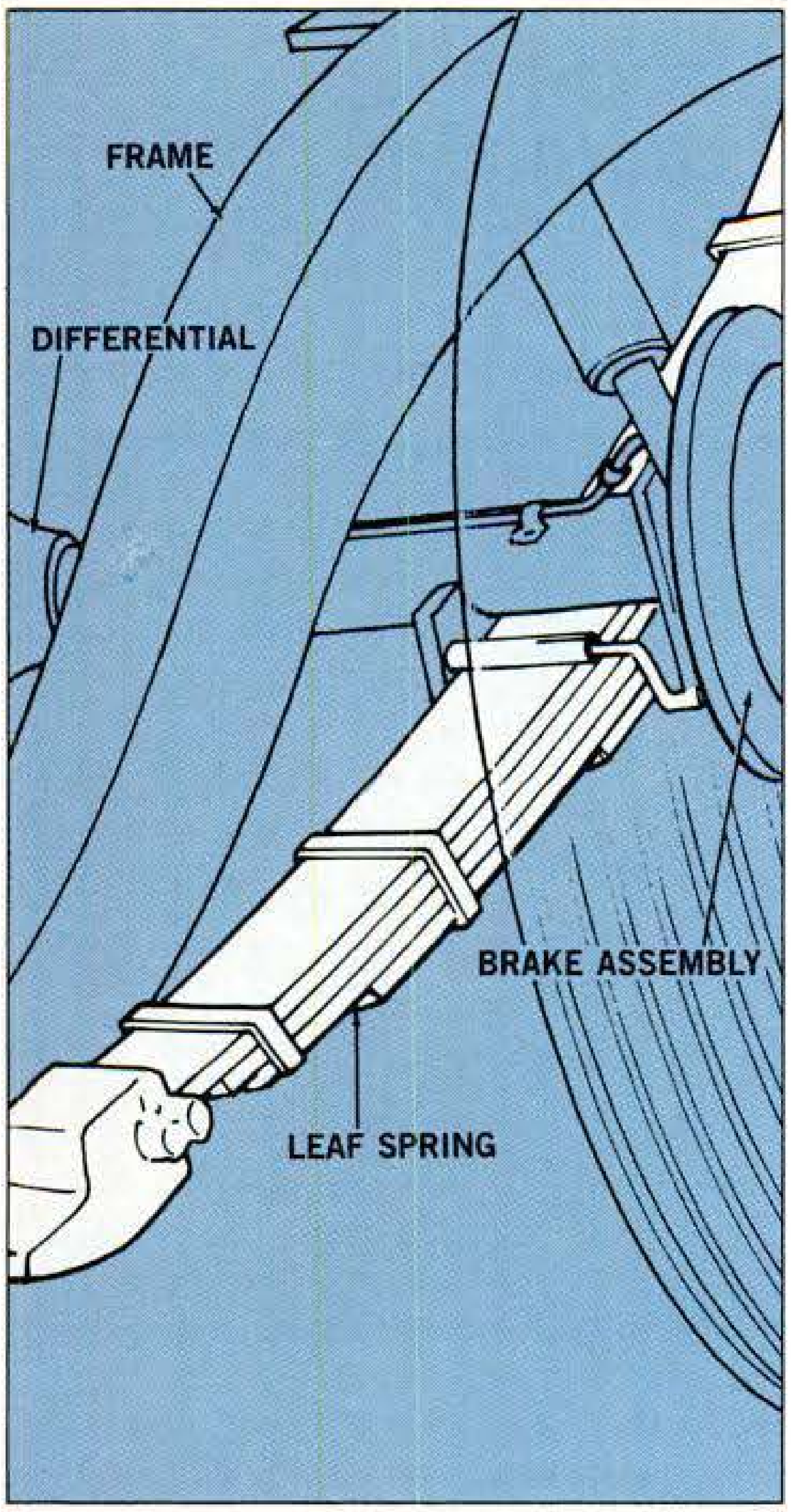
Spark thieves

Starter components that draw excessive amounts of current from the battery can sometimes rob the ignition circuit of power, causing a hard- or no-start condition. If you get a weak or intermittent spark when troubleshooting a starting problem, always test the cranking circuit before condemning the ignition parts.



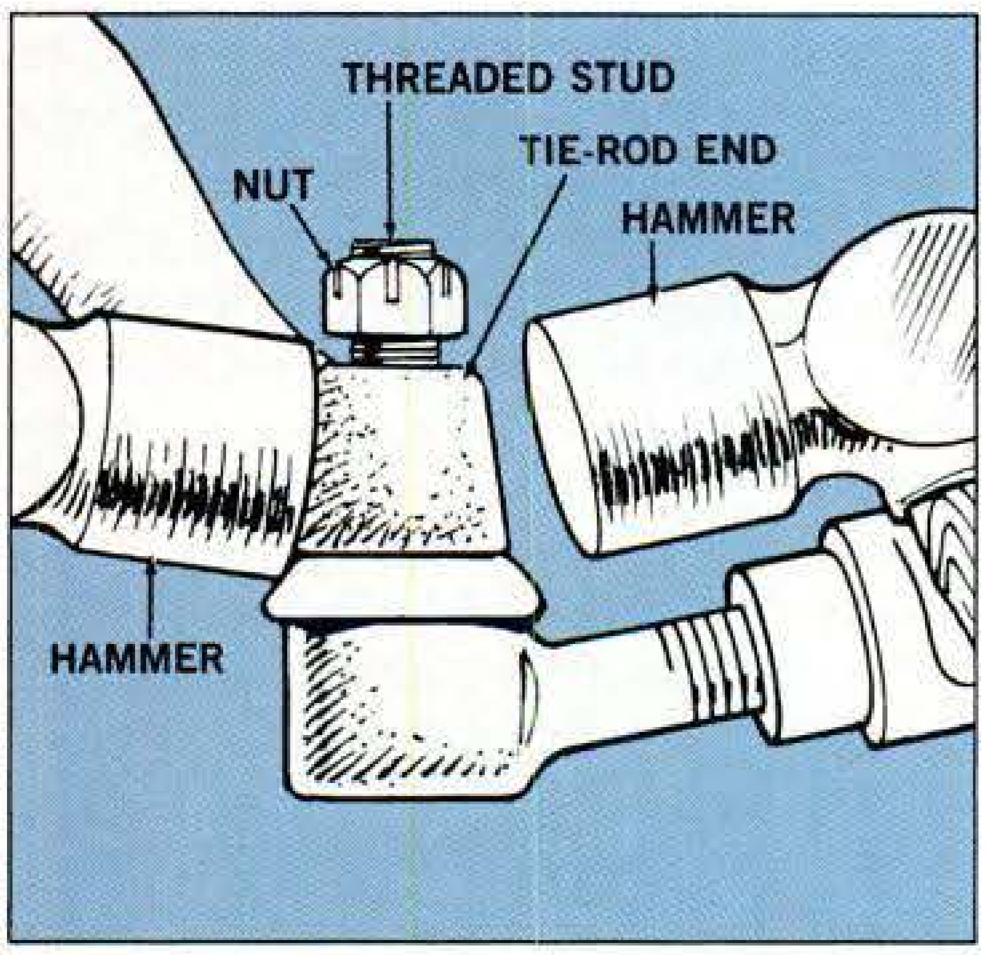
Wing-nut muscle

Over-tightening the air-cleaner wing nut or nuts can lead to a warped carburetor and an internal vacuum or air leak. Surging, hard starting, and erratic idle are some of the symptoms. To avoid this problem, use your hands —never a wrench—to snug the nut. It won't tighten? The air-cleaner gasket may be worn or missing.



Squeak squelch

Sometimes it seems impossible to stop a leaf spring from squeaking. Lubricants tend to wash out and even attract dirt that aggravates the problem. A nearly foolproof method of stopping this noise is to install small Teflon (fluorocarbon resin) pads between and at the ends of the leaves.



Hammer how-to

Driving the tapered end of a tie rod out of a ball joint by striking the end of the threaded stud is a time-consuming and destructive method of disassembly. Instead, try smacking the side of the joint with a hammer while backing the other side with a second hammer. Loosen, but don't remove, the nut for thread protection.

WHAT DO YOU SCORE ON THIS WOODWORKER'S TEST?

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So grab a pen or pencil and get started!

Circle A, B or C for each question:

1 How much experience have you had in woodworking, home repair and maintenance?
(A) Little or no experience
(B) Some experience
(C) Quite a bit of experience

2 Which phrase best describes your workshop?
(A) A selection of hand and portable power tools
(B) A table or radial arm saw, hand and portable power tools
(C) A good selection of stationary and portable power tools

3 How involved do you want to become with woodworking, home repair and maintenance?
(A) Not very involved
(B) Moderately involved
(C) Heavily involved

4 What's the likelihood that you'll buy a woodworking tool within the next year?
(A) Not likely
(B) Somewhat likely
(C) Highly likely

5 Which best describes you?
(A) I do some home repairs and maintenance
(B) I do some woodworking and a variety of home repairs
(C) I'm primarily interested in fine craftsmanship woodworking

How to find your score:

Simple! Count nine points for each (A), six for each (B), three for each (C). Then enter your total on the coupon, fill in your answer for Question #5, include your name and address and mail to Shopsmith!

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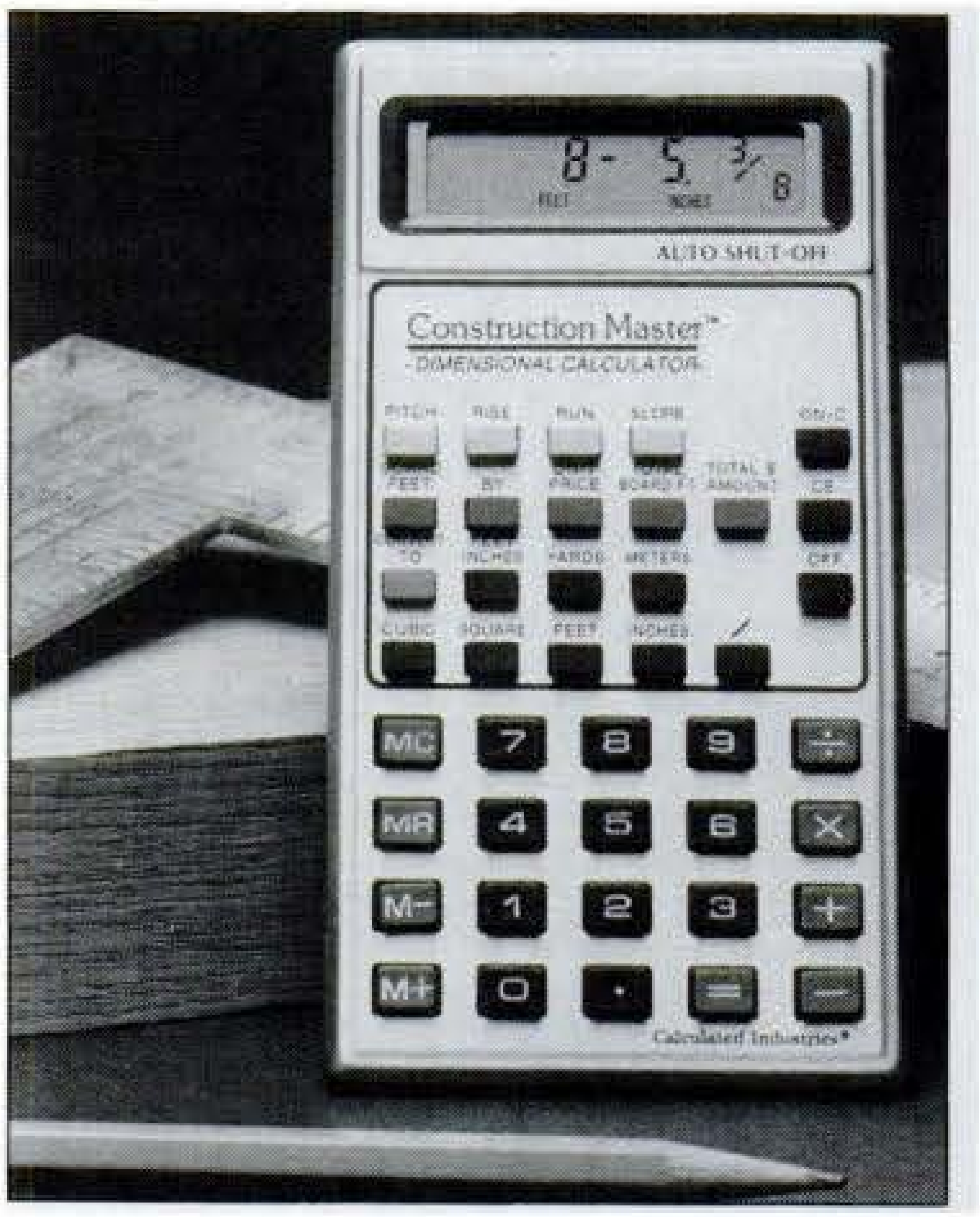
Shop-talk calculator

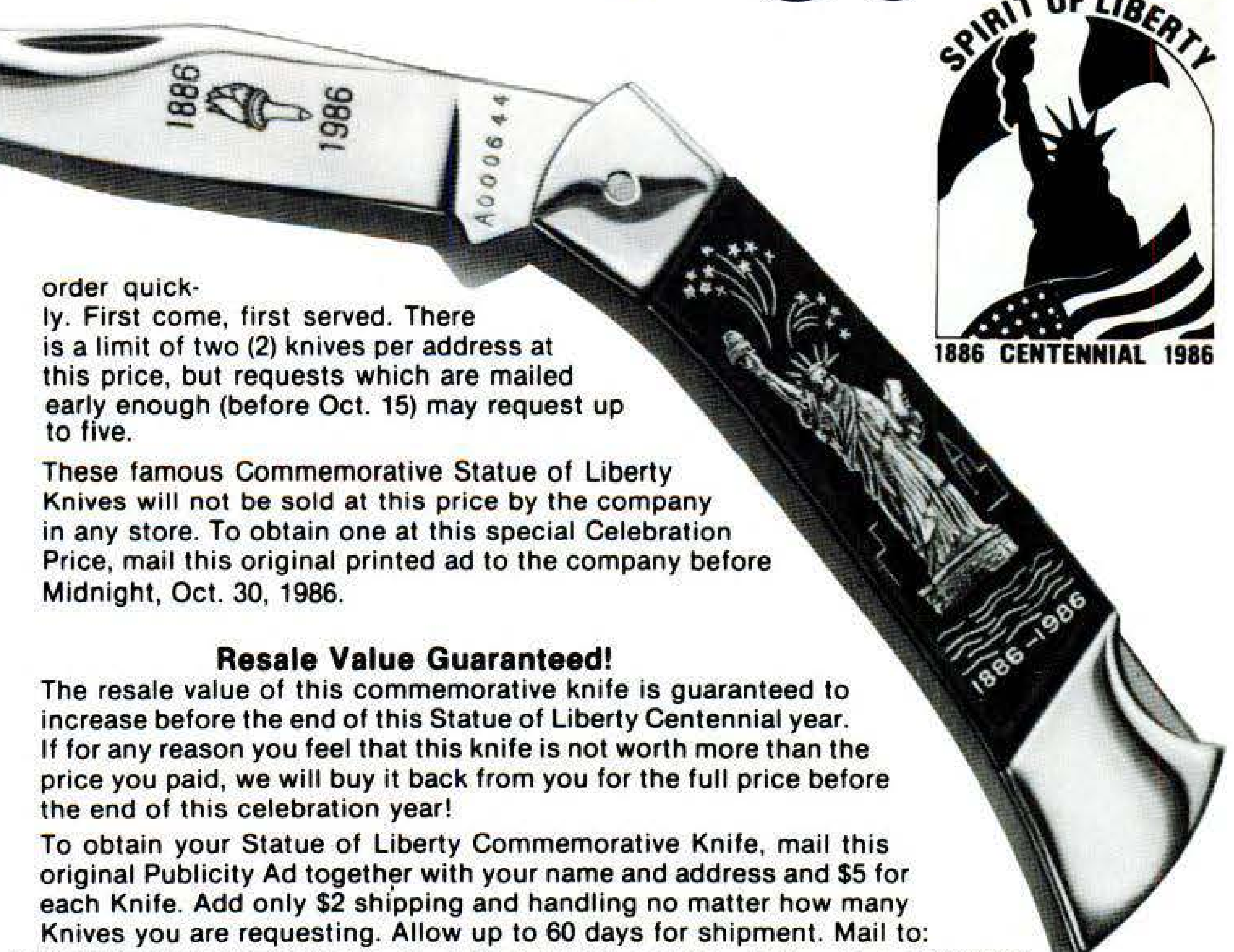


As handy as pocket calculators are, they've never been much help to me in my shop. They think in the decimal system, and the workshop is still mired in the world of feet and inches. But now I've found a calculator that solves that problem. It's a four-function calculator with two independent memories that's preprogrammed to handle shop and construction math. For example, you press special keys to calculate roof pitch, rise, slope, and run; board feet; and costs. Press other keys, and the clever calculator performs instant conversions, such as inches to feet, yards to meters, and cubic feet to cubic yards.

What I like most is the way it speaks my language of feet, inches, and fractions of inches, and the effortless way it handles pesky fractions. It adds, subtracts, multiplies, and divides them, and there's no need to worry about common denominators. Just enter the fractions, and the calculator spits out your answers to the nearest 1/64 inch.

All this makes child's play out of problems like "I want five drawers to fit a 34¼-inch space. How deep must each one be if I want a 3/16-inch gap at the top and bottom and between each drawer?" (Answer: 6⅝ inches.)

The Construction Master Dimensional Calculator is $93.45 (ppd.) from Calculated Industries, 2010 N. Tustin Ave., Suite B, Orange, Calif. 92665. It comes with an excellent manual filled with examples of all kinds of construction and shop calculations. —*A. J. Hand*



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This original Publicity Ad must accompany your request. Copies or photostats are not acceptable.

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SPIRIT OF LIBERTY
1886 CENTENNIAL 1986

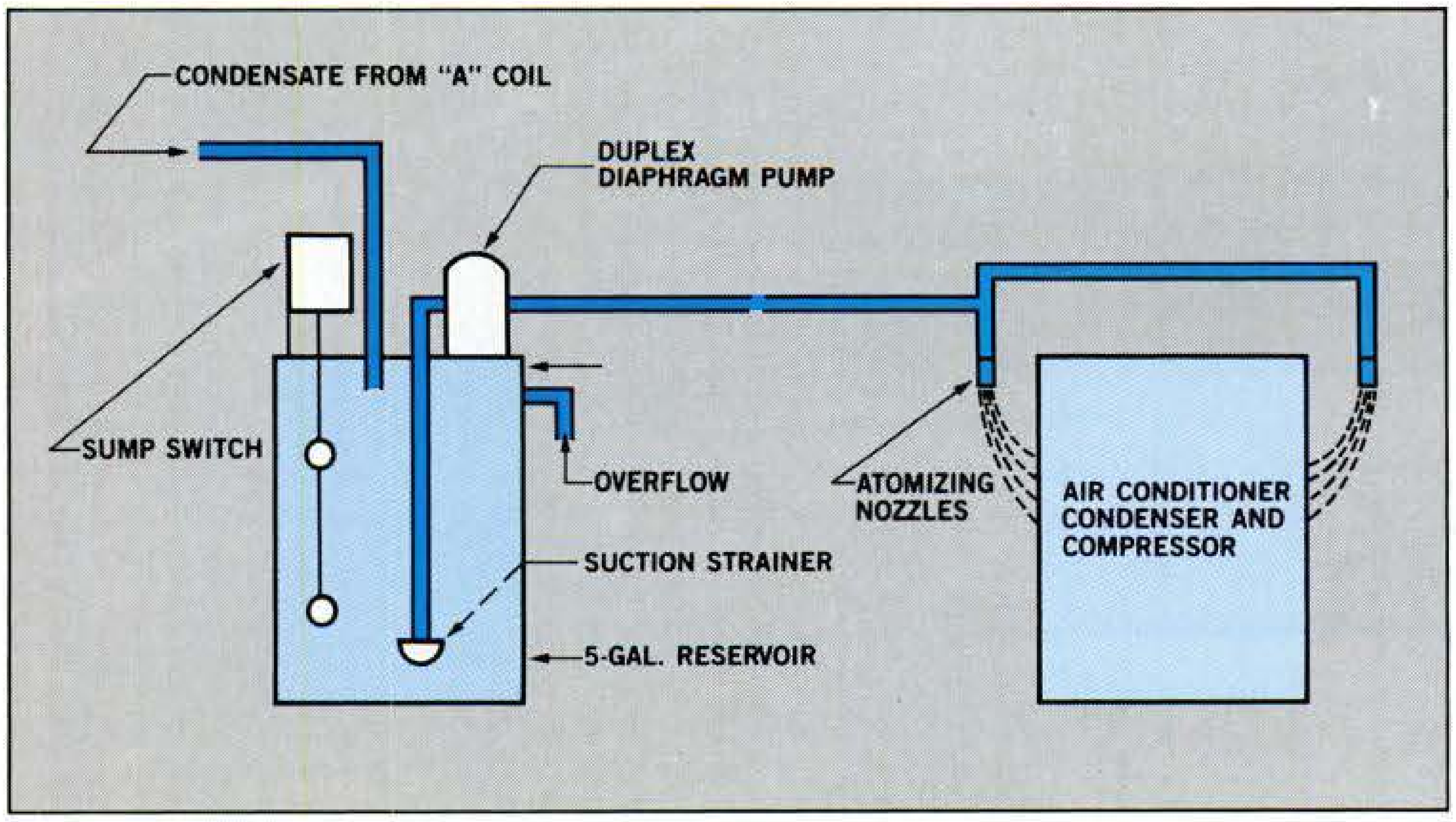
A/C mister cuts cooling costs

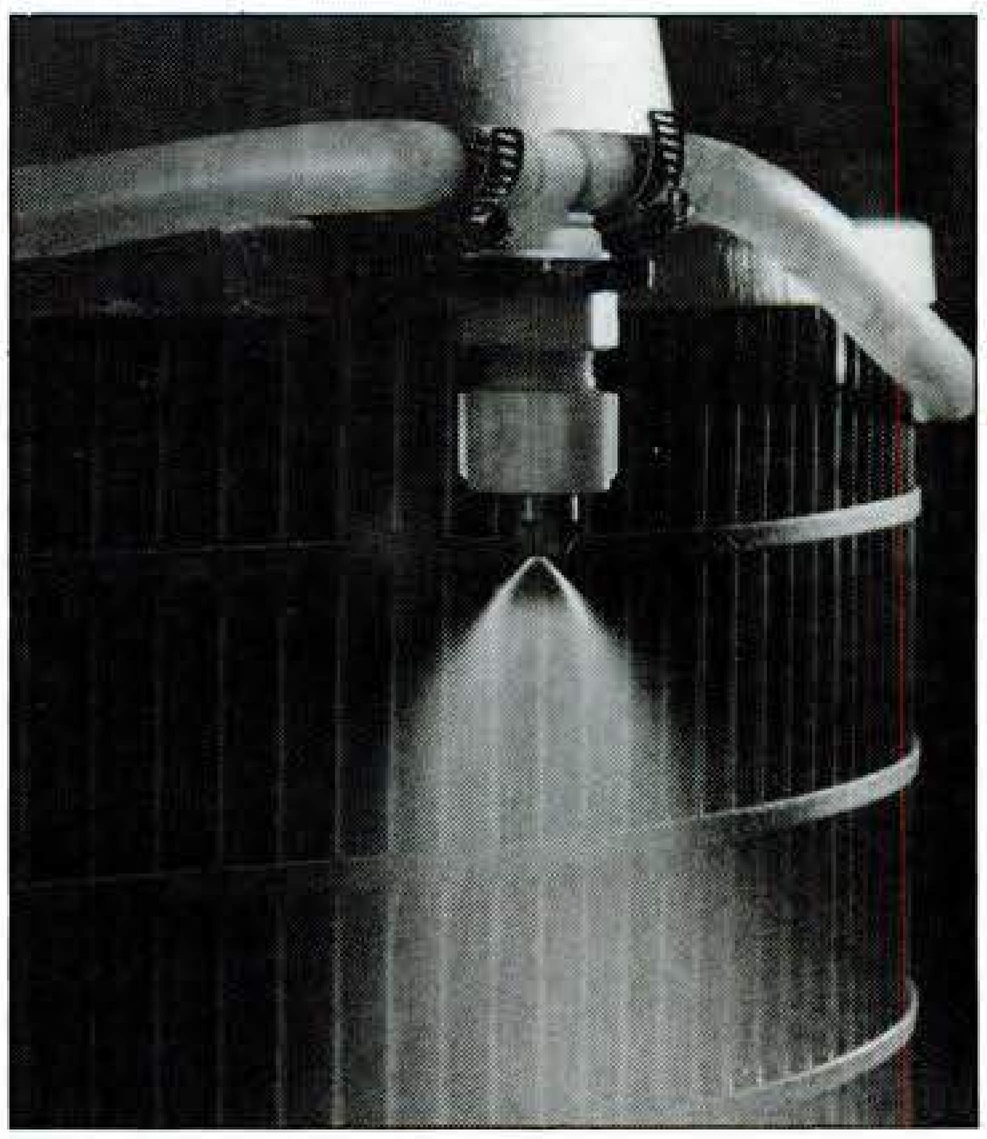
When the summer heat reached 100 degrees F, Alfred Buhl was able to cool his Pacific, Mo., house to only 80 degrees—using two air conditioners. Frustrated, he almost bought a third, but instead bought a CondenSaver, a small add-on device. It brought the temperature down to 65.

"The basic idea," says Tim Kimsey, president of CondenSaver (Kansas City, Mo.), "is to cool the air being drawn into the condenser, thereby fooling your air conditioner into thinking the outside temperature is considerably cooler. This makes it run more efficiently."

Three nozzles spray a fine mist of water onto the condenser coil. As the water evaporates, it cools the coil. The water used is the condensate wrung from the indoor air. A 40-watt pump delivers the condensate to the condenser through plastic tubing.

Though A/C misters are not unique, the CondenSaver's use of condensate instead of tap water saves the condenser's aluminum fins from corrosion due to chlorine and mineral deposits. Kimsey claims that this energy saver, at $179, can pay for itself in two years.
—*Genevieve Capowski*





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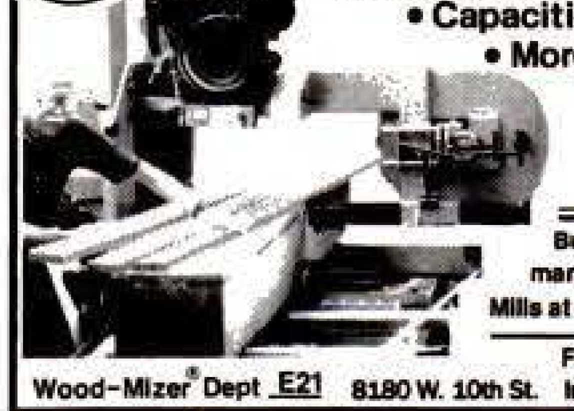

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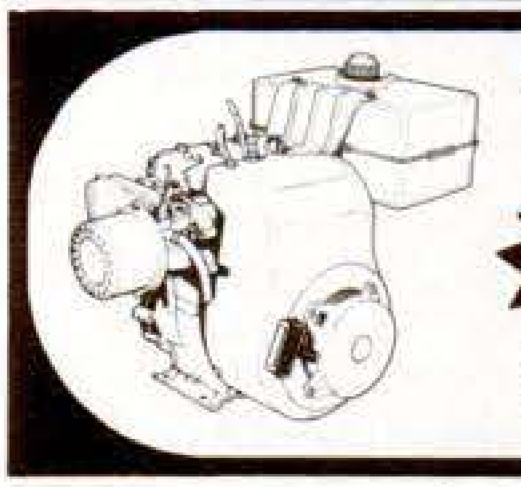

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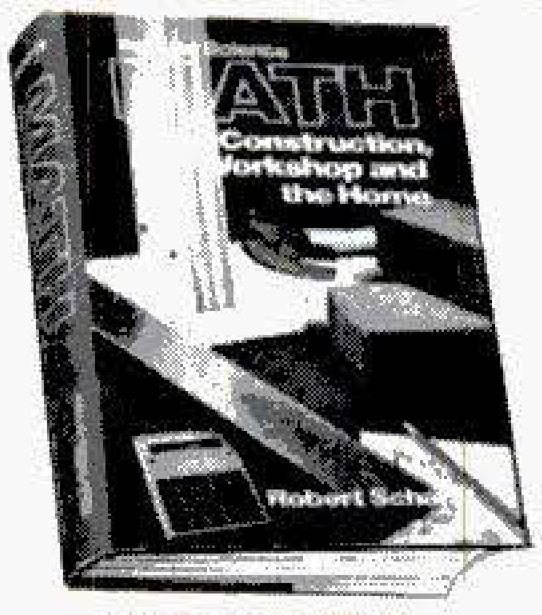

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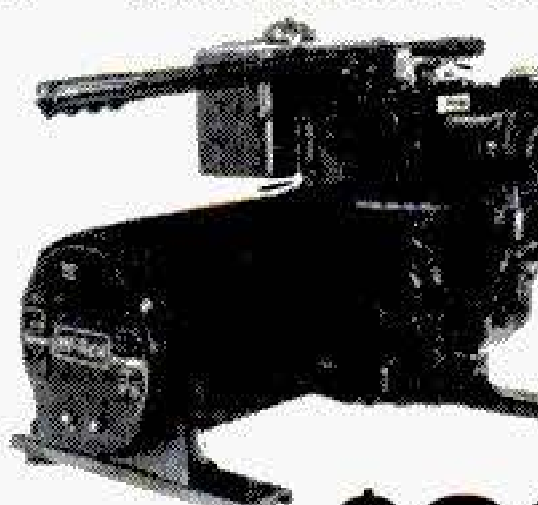

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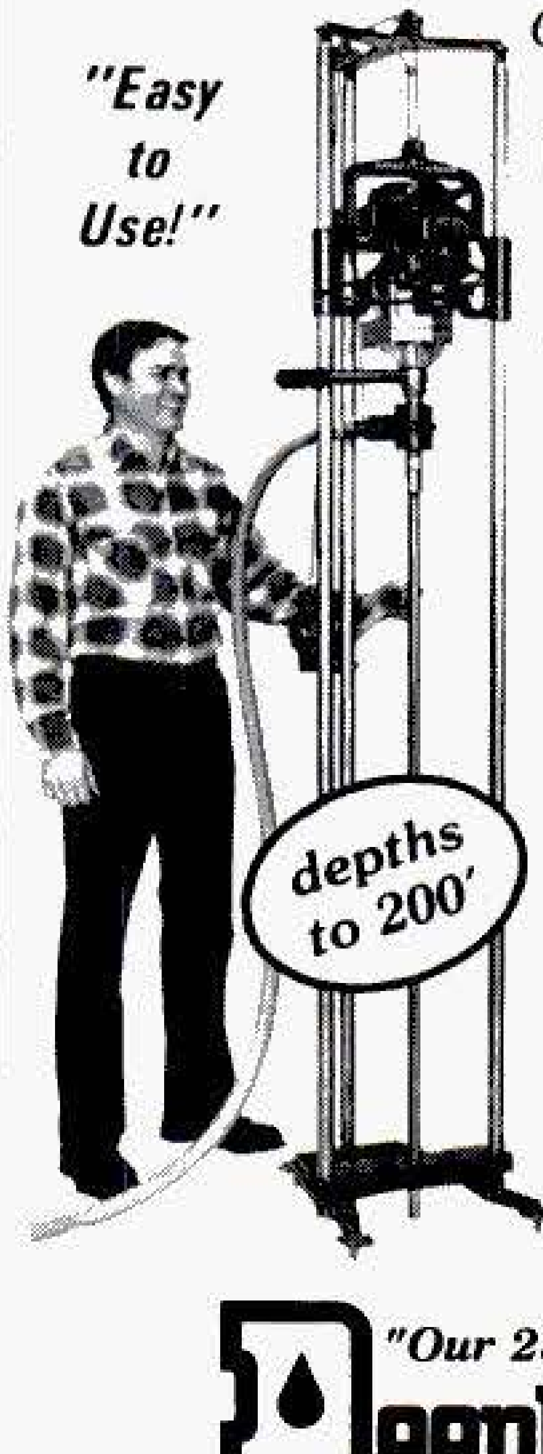

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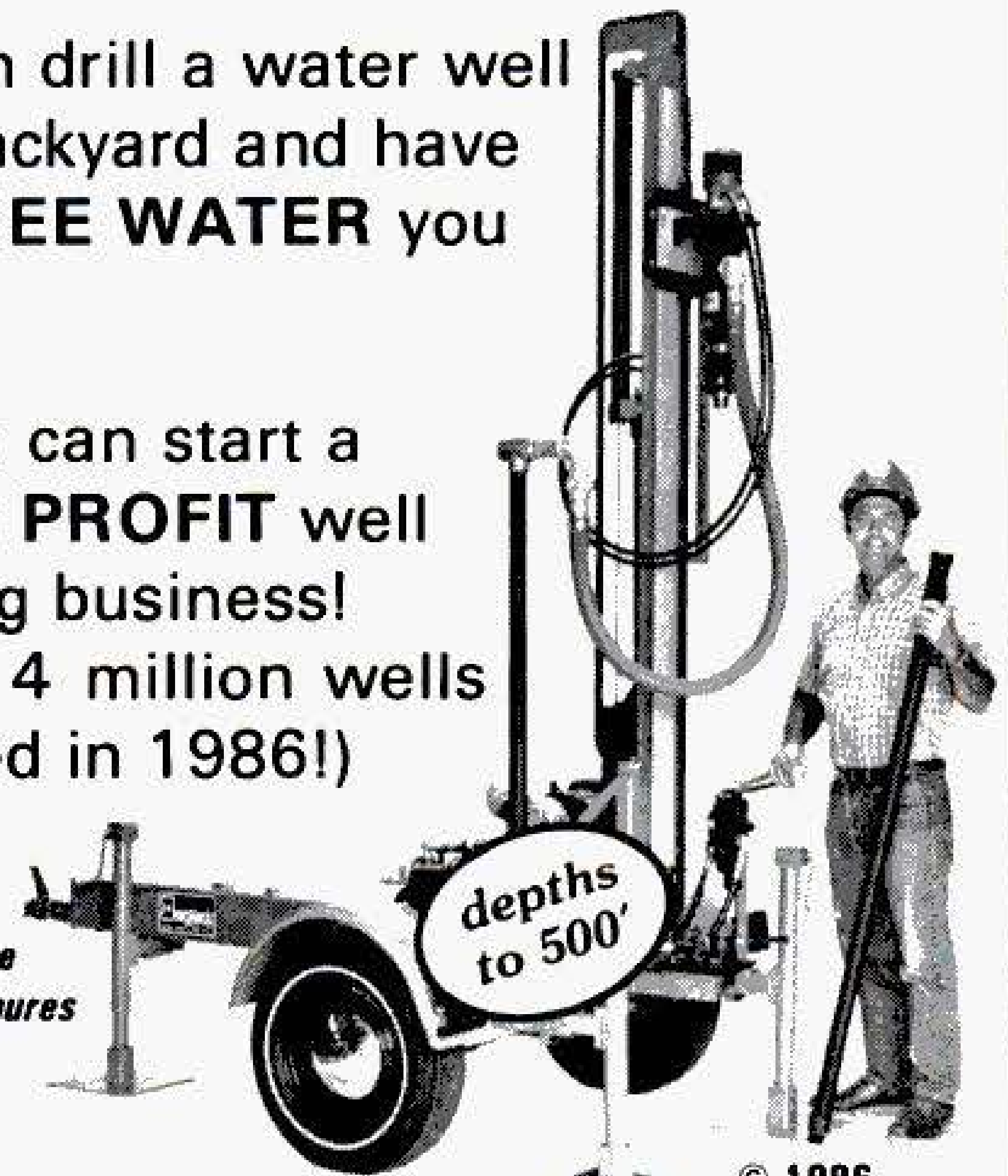

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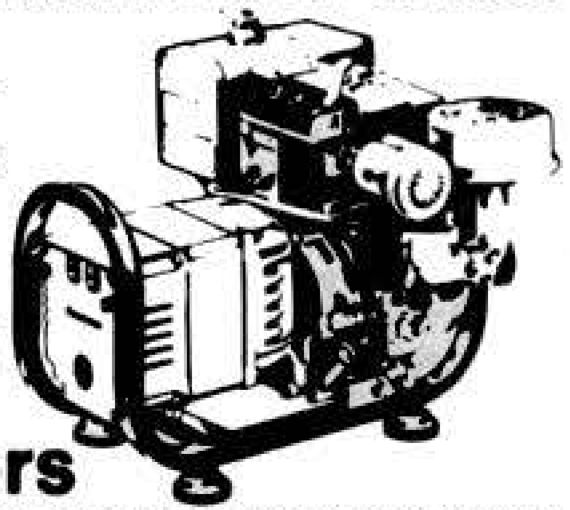

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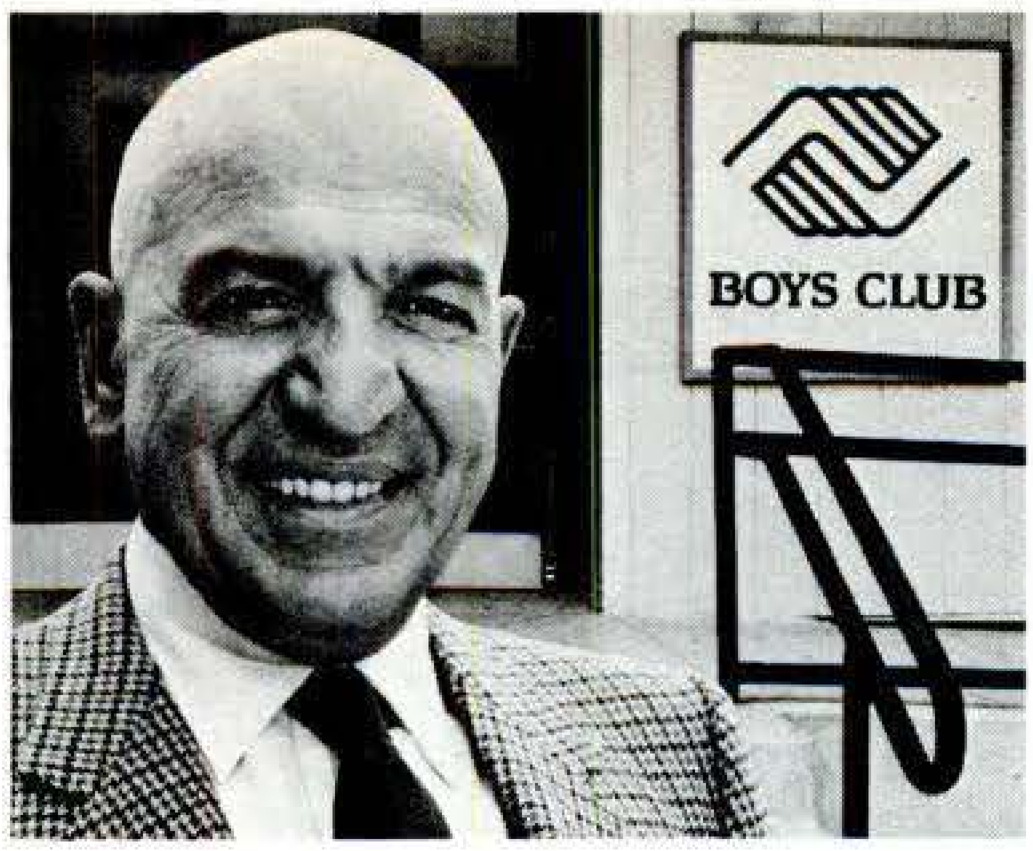

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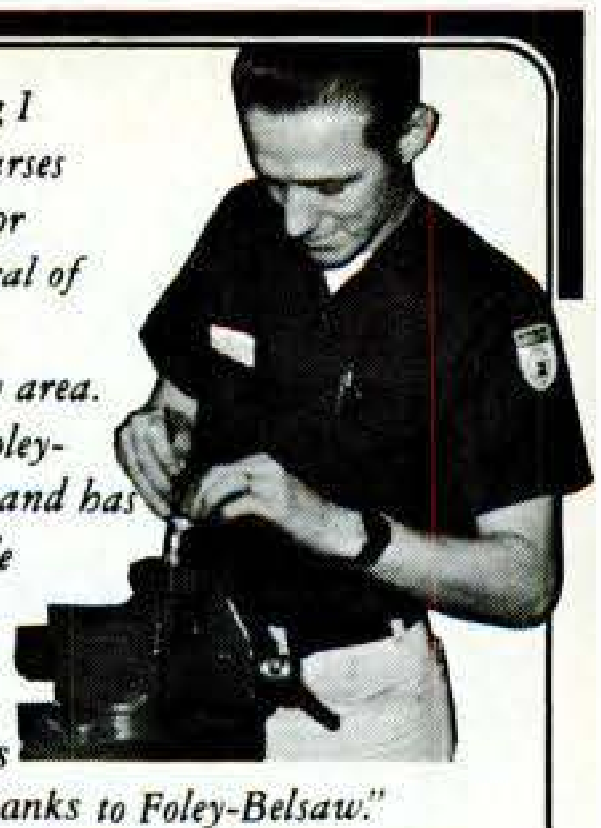

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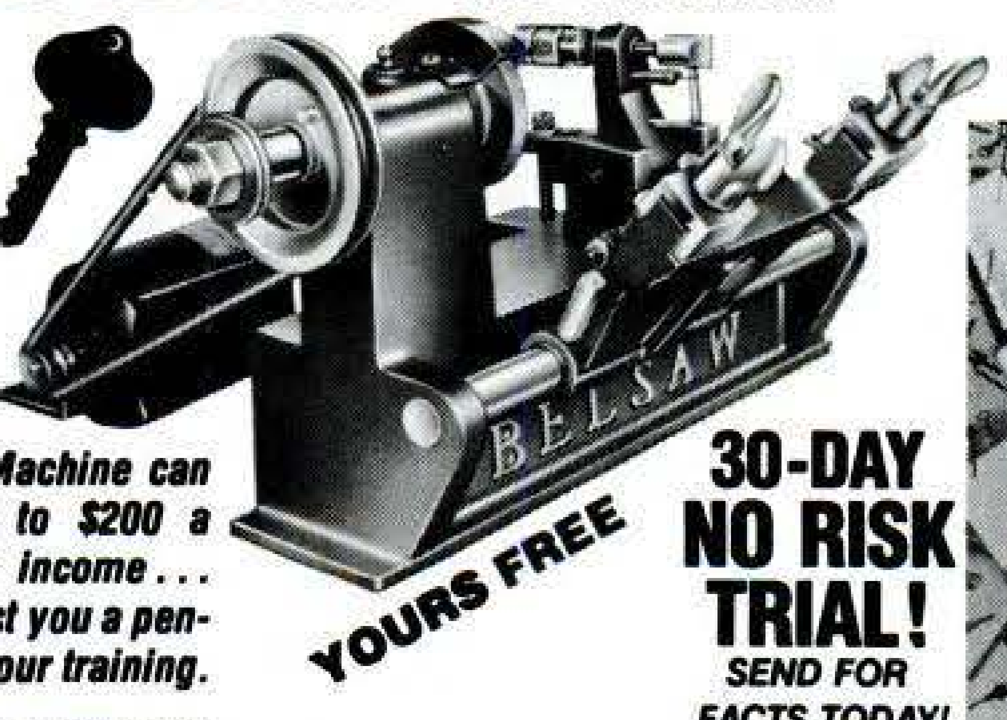

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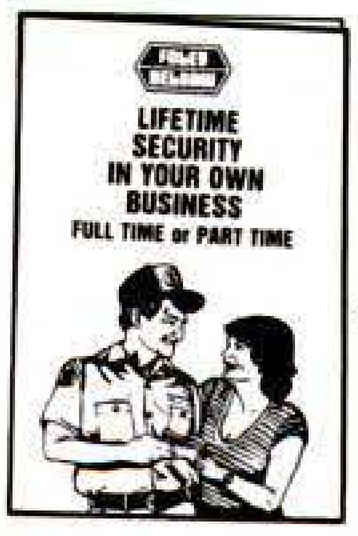

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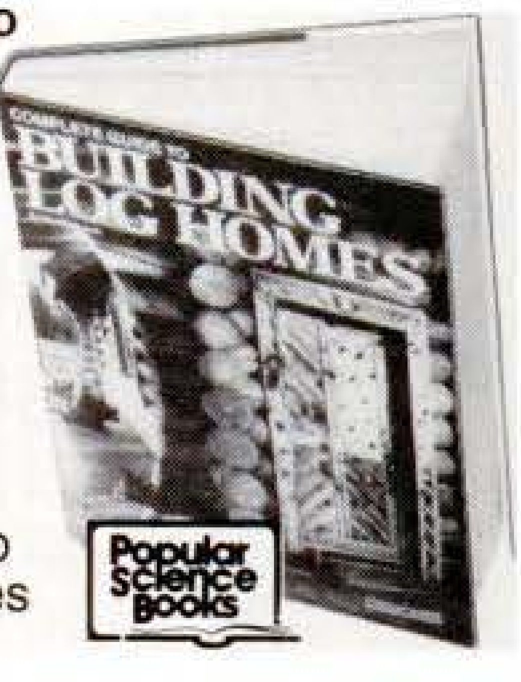

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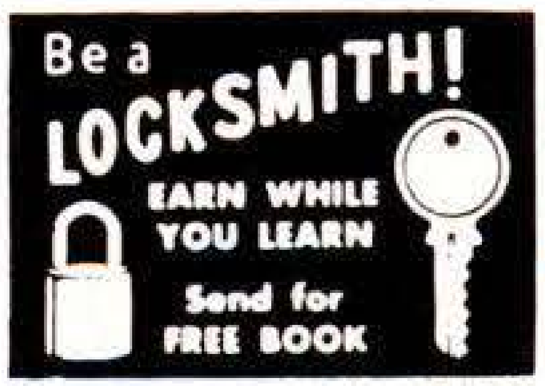

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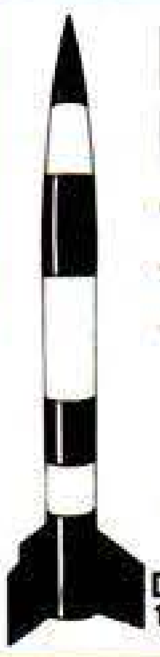

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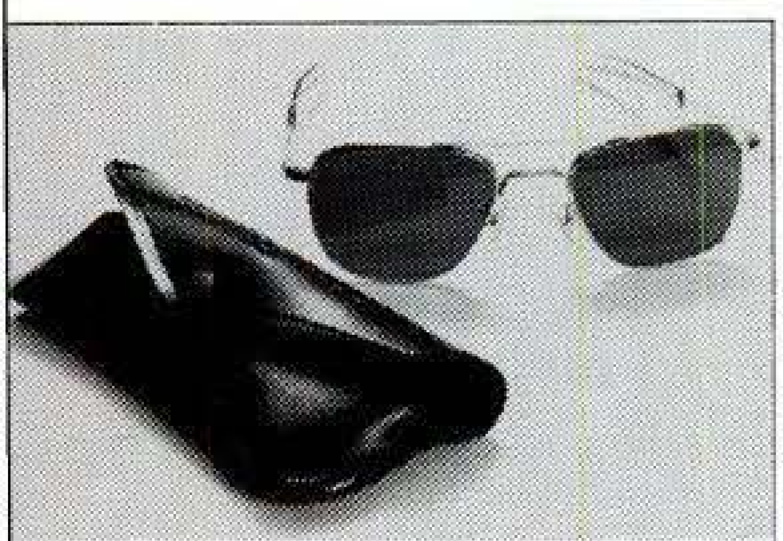

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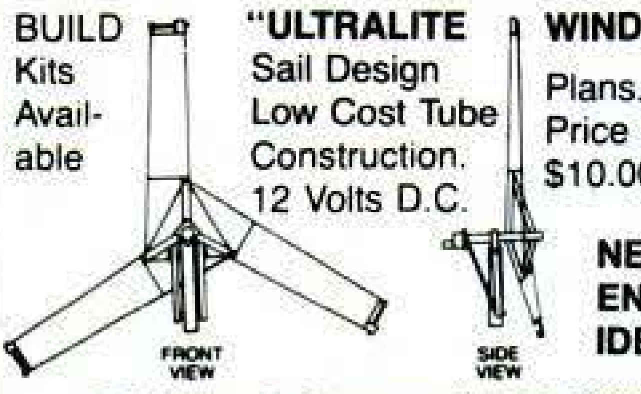

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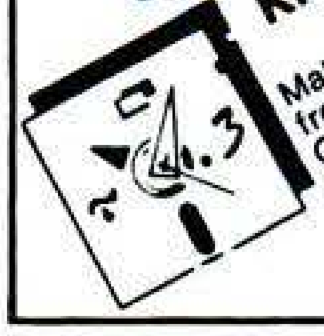

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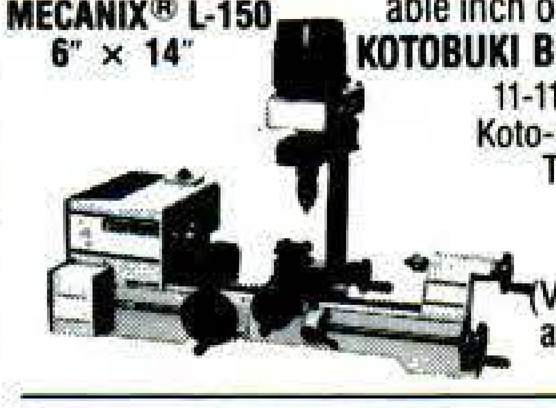

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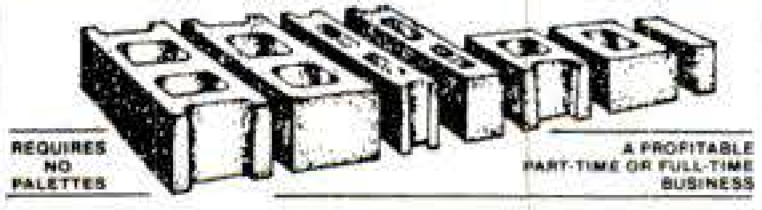

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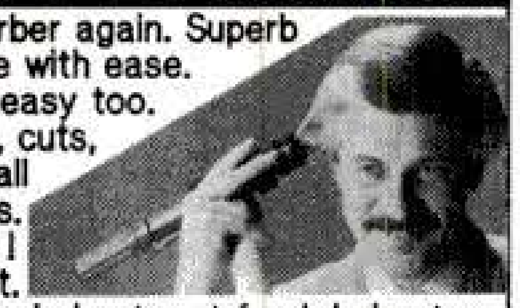

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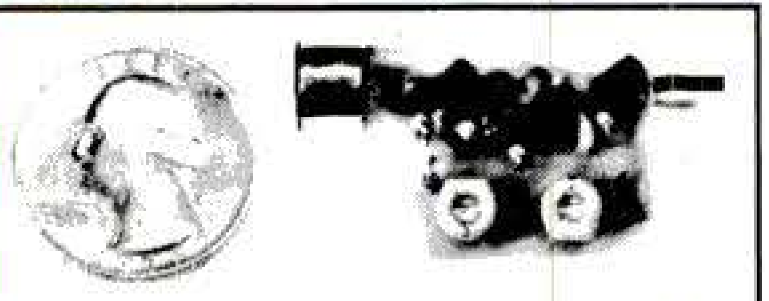

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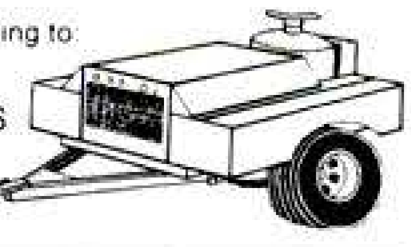

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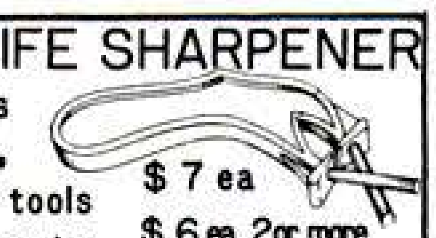

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801 Furniture Refinishing Klean Strip's eight-page color brochure shows how to refinish wood furniture without stripping or sanding. From W. M. Barr & Co., the literature includes tips on minor repairs and wood furniture care. Free

802 Boating Bayliner Marine's new catalog displays the firm's complete line for 1986. Sporty runabout packages to world-class luxury motor yachts are featured, all with the high quality, standard equipment, and value that Bayliner provides. Free

803 Redwood Decks An eight-page booklet from the California Redwood Association provides information on redwood deck construction, including beam, joist, and decking spans, and nailing and finishing tips. 50¢

804 Speed Boats A 32-page full-color 1986 catalog from Donzi Marine lists its internationally known line of high-performance 18- to 33-foot fiberglass speed boats. $5

805 Car Paint Repair Dupli-Color's 18-page "Auto Touch-Up Guide" gives step-by-step instructions for car paint repair for nicks, scrapes, and rust. The company's complete product line is listed. Free

806 Cutting Tools A new 104-page Freud catalog displays its finest quality hand tools and carbide cutting tools, from chisels to saw blades to router bits. $1

807 Home Designs A full-color 112-page catalog from Home Planner features 125 contemporary home designs. The unique yet practical and economical plans feature sloped ceilings, indoor and outdoor balconies, upper-level lounges, passive solar glass, and more. Blueprints are available. $2.95

808 Gardening Color literature from Mainline of North America describes the sturdy, versatile Mainline ML 35 garden cultivator. It weighs only 21½ pounds, has a two-horsepower two-stroke engine, and folds for easy storage and transport. Free

809 Outboards Mercury Marine's brochure describes its 1986 outboards, including the all-new, smoothest-ever 6-, 8-, and 9.9-horsepower fishing outboards, with full gear shift and tilt in the handle. The country's most popular bass outboard, the XR2, has been joined by a new 135-hp V6. Free

810 Professional Knives This full-color brochure from Morty the Knife Man lists its full line of quality knives at wholesale prices, plus sharpening equipment. Free

811 Leisure Boats Godfrey Marine's two color catalogs feature its line of cruising, fishing, and water-skiing boats, including 19 low-cost inboard and outboard designs. Free

812 Concrete Building and Repair This 165-page hard-cover book from Quikrete provides step-by-step instructions for concrete construction and repair. Dozens of projects are listed, including walls, foundations, and patios with helpful illustrations. $7.95

813 Flat Tires Literature from Reinhart Industries provides information on its Lug Buster tool, which makes it easy for anyone to change a flat tire Even corroded, frozen lug nuts are simple to remove. Free

814 Home Security This color brochure explains Schlage Lock's KeepSafer home security system, with features comparable with most professional systems. The system is affordable and easy to install. Free

815 South Carolina Vacation Guide A 64-page full-color catalog from the South Carolina Division of Tourism features the state's historic cities, uncrowded beaches, world-famous gardens, cool blue lakes, green mountains, and graceful plantations. Great dining spots and shopping locations are also described in the book. Free

816 Tools This 72-page full-color catalog lists hundreds of quality tools and products for your house, car, boat, or plane. It's from Sporty's Tool Shop. $1

817 Automatic Sprinkler Systems Enjoy more free time. An informative brochure from Toro tells homeowners about the benefits of automatic underground sprinkler systems. It also provides helpful hints on lawn care and PVC plastic pipes. Free

818 Windows and Skylights Velux-America's 24-page full-color booklet, "The Complete Guide to Roof Windows and Skylights," describes Velux roof windows, skylights, and accessories. The literature also includes facts about installation in different types of roofs and answers questions about ventilation and energy-saving features. Free

819 Hot-Spring Spa Watkins Manufacturing's color catalog describes the company's hot-spring spa line. The spas are completely portable, self-contained, and 100-percent foam-filled for maximum energy efficiency. The name and telephone number of your local dealer is also included. Free

820 Satellite TV "All You Need to Know About Satellite TV," an informative booklet from Winegard, answers the most-asked questions about home satellite television. It includes valuable illustrations and a glossary of technical terms. Free

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Note: POPULAR SCIENCE Massachusetts address is for Product Information only.

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